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REPORT OF THE

NAVAL AVIATION BIOMEDICINE/HUMAN EFFECTIVENESS TECHNICAL WORKSHOP

Fiscal Year 1974

DEPARTMENT OF THE NAVY

Enclosure (1) To CNO Serial 41 of 18 Feb 74

From: Chairman, Naval Aviation Biomedicine and Human Effectiveness Technical Workshop
To: Distribution List

Subj: Letter of Promulgation

1. This report presents the findings and conclusions of the FY 1974 Naval Aviation Biomedicine and Human Effectiveness Technical Workshop.

2. It was the intent of the Workshop membership to develop a body of information of value for the guidance of biomedical research, development, test and evaluation planning and effort in support of our future aviation programs. This material is transmitted for your review and use.

R. G. Ireland

ROGER G. IRELAND
Captain, MC, USN

Final Report

NAVAL AVIATION BIOMEDICINE AND HUMAN EFFECTIVENESS TECHNICAL WORKSHOP

Conference Supported by

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Charleston, South Carolina

Prepared by

BioTechnology, Inc.

Administrative Summary

The FY 1974 Naval Aviation Biomedicine/Human Effectiveness Technical Workshop met to review Navy RDT&E programs in support of aviation medicine and to make recommendations regarding objectives and priorities for future research. The Workshop provided an excellent opportunity for members of the user community (Fleet aviation personnel and aviation planners) and the producer community (RDT&E scientists and engineers) to exchange relevant information and to discuss issues relating to the conduct of Navy research programs in support of aviation medicine.

The first part of the Technical Workshop consisted of a two-day briefing held in Washington, D.C. on 26 and 27 July 1973. Naval personnel concerned with a number of aviation planning programs described the advanced technology and prospects for naval aviation systems of the future. They also discussed, to some extent, the biomedical and human effectiveness issues they felt would be raised through use of these new systems.

The Technical Workshop itself was held in Charleston, S.C. on 6-10 August 1973. The work of the conference was done by four subcommittees covering the content areas of (1) Aviation Operational Medicine, (2) Physiological Assessment, (3) Life Support and Survival Systems, and (4) Human Effectiveness. Each committee presented conclusions relating to its specialized field of interest. These are presented in the final report.

The specific work activities and results accomplished by the Technical Workshop included:

1. *Review of Future Operational Requirements and Programs.* Research personnel were able to familiarize themselves with the likely nature of naval aviation in 1980 and beyond as well as the RDT&E requirements foreseen by planning personnel.

2. *Evaluation of Ongoing Research Units.* All ongoing RDT&E work units were reviewed to assess the relevance of current research in light of projected requirements.

3. *Definition of Research Objectives.* New research objectives were defined based on mission requirements and flight characteristics for the coming generation of aircraft and aviation systems. This involved both new topics for R&D and changes in the direction of ongoing programs.

4. *Establishment of Research Priorities.* Recommendations for new research were ordered, in most instances, in terms of relative priority based on relationship to direct mission needs, adequacy of similar ongoing research, and possible overlap with research supported by other government agencies.

The final report should serve as a guide for the planning and conduct of Navy RDT&E programs in support of naval aviation medicine until such time as the nature of aviation missions and development programs changes.

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OPENING ADDRESS

THERE ARE MORE THAN TWO R's AND ONE C IN NAVY RESEARCH!

Rear Admiral Philip O. Geib, MC, USN
Assistant Chief for Research and Military Medical Specialities
Bureau of Medicine and Surgery

It is an honor and a privilege to welcome you to the opening session of the Technical Workshop for Aviation Biomedicine and Human Effectiveness. As most of you know, the Chief of Naval Development and the Chief of Naval Research sponsored a Technical Working Group Meeting in Orlando in February of 1969 on this subject. The present meeting, sponsored by the Research Division of the Bureau of Medicine and Surgery, is planned to update and expand on the findings of that Working Group.

As I look around me, I see flight surgeons, physiologists, psychologists, research scientists and administrators, engineers, and aviators. This multidisciplinary group represents the Chief of Naval Operations, ONR, NAVMAT, NAVAIR, our laboratories, and most important, the operational Navy – a fine mix to accomplish the job at hand. The purpose of the meeting is to determine the needs of the Navy and Marine Corps for research in support of Aviation Medicine and Human Effectiveness, evaluate the ongoing program, set priorities, and make recommendations on the future program, making sure the program is *Required, Relevant,* and *Reliable.*

Lest you feel that the Navy Medical Department has no future five or ten years from now, let me reassure you that it is very much alive. There are many changes which have to be accepted, but this is progress. As you may already know, plans have been formulated for our Research Division to attain Command status this fiscal year. Next month Admiral Waite will be added to the Surgeon General's Staff and will be tasked with working out the restructuring of the One-Digit Codes into Operational, Research, Education, and Training Codes to be implemented by 1 July 1974. There will soon be a new office established, the Health Systems Program Office (HSPO), which will be the focal point between BUMED, CNO, ASN (R&D and ASD [H&E]). The Program Manager will be under the control of the Deputy Surgeon General (Code 2).

Aviation Medical Research can point with pride to its many accomplishments since its beginning. I need not remind you of the many spinoffs of your efforts to clinical medicine and the space program. What of the future? These next two weeks will be your chance to help shape it.

Let me sympathize with you nonresearchers at this Workshop. When I reported to BUMED last year, after 27 years in clinical medicine, I discovered that one of my divisions was the Research Division (Code 71). Soon after my briefing began, I realized that I did not understand the language. I saw that this might be one of the reasons for the lack of understanding between the research and the nonresearch communities. The nonresearch community did not seem to know that the products of research are most vital to the progress of medicine. Nonresearchers are too often impatient, expecting too much too soon, and are painfully unaware that a usable product does not materialize with any predictable frequency. I hope that by the end of this meeting we will begin to be able to understand what each other has to say.

The definition of research is that it is a careful, systematic, patient study and investigation in some field of knowledge, which is undertaken to establish facts or principles.

As we master the language, we will realize that there are three very important R's to military research: (1) *Requirement,* (2) *Relevance,* and (3) *Reliability.*

Requirement – A problem must be identified with enough priority for the field of aviation in general (that is, peculiar to the Navy) in order for it to be considered. Of course, the solution to the problem must have some hope of success in a reasonable length of time.

Relevance – The product must be needed by the Navy. Civilian applicability is only incidental. Research products will not be approved unless they are relevant, and if they lose their relevance, they will not be funded. It is as simple as that.

Reliability – Quality of the product is obviously important to the user. It is also important to the research community, military and civilian, as a measurement of expertise in any laboratory. We want to be among the best.

In addition to the three R's in Research, I am sure you did not realize there are also three C's in the word. These are: *Communication, Coordination,* and *Cooperation.*

Communication is vital to the research community. A breakthrough in engineering may be just the thing we need, if we but knew of it. Our tasks here this week will not be successful unless we understand what we are saying to each other. I would like to ask that you research scientists use as few acronyms and abbreviations as possible, and, when indicated, define them. To you nonresearchers, I suggest that you do not hesitate to ask questions.

In addition to communication, we must also *cooperate* with other investigators in the field and *coordinate* our programs within the Navy, DOD, and other Federal agencies to ensure there is no unnecessary duplication of effort. It is imperative that each investigator at the bench level be aware of what is going on in his field, so that he may avoid repeating ongoing or previously completed research. We do not need to re-invent the wheel. All of our programs are being more closely scrutinized now, and duplication of effort will certainly not help us.

Recently, I read an article by Dr. Lewis Thomas in the *New England Journal of Medicine* on the technology of medicine. Dr. Thomas divided medical technology into three parts. He called the first Nontechnology, which is supportive therapy that has been developed to tide the patient over until he dies, such as the care given in intractable cancer or multiple sclerosis cases, or even an aspirin given for a headache. Most are important products, but they are usually not scientifically derived.

The second part of medical technology, as defined by Dr. Thomas, is the Halfway Technology designed to make up for the disease, or to postpone death, such as transplantation of hearts, kidneys, and livers. If we had been developing preventive measures, the transplantation would not be necessary.

The third type of technology is the kind that is so effective that it attracts the least public notice. It has come to be taken for granted. This is the Genuinely Decisive Technology of modern medicine. It is exemplified best by modern methods for immunization against diphtheria, pertussis and the childhood virus diseases, and the contemporary use of antibiotics and chemotherapy for bacterial infections.

The point to be made about this kind of technology – the really high quality technology of medicine – is that it comes as the result of genuine understanding of the basic disease mechanisms, and when it becomes available, it is relatively inexpensive, simple, and easy to deliver.

I cannot think of any important human disease that medicine possesses the capacity to prevent or cure outright where the cost of the technology is itself a major problem. The price is never as high as the cost of managing the same disease during the earlier stages of Nontechnology or Halfway Technology. If a case of typhoid fever were to be treated today by the best methods of 1935, it would run into staggering expense. At, say, around 50 days of hospitalization, requiring the most demanding kind of nursing care, with the obsessive concern for details of diet that characterized the therapy of that time, with daily laboratory monitoring and, on occasion, surgical intervention for abdominal catastrophe, I should think $10,000 would be a conservative estimate for the illness, as contrasted with today's cost of a bottle of chloramphenicol and a day or two of fever.

Pulmonary tuberculosis had similar episodes in its history. There was a sudden enthusiasm for the surgical removal of infected lung tissue in the early 1950's, and elaborate plans were made for new and expensive equipment in tuberculosis hospitals. Then NIH and streptomycin came along, the hospitals themselves were closed, and the patients treated at home.

It is when physicians are bogged down by their incomplete technologies and by the innumerable things they are obliged to do when they lack a clear understanding of disease mechanisms, that the deficiencies of the health care system are most conspicuous. If I were a policymaker, interested in saving money for health care over the long haul, I would regard it as an act of prudence to give high priority to more basic research in Biologic Science. This is the only way to get the full mileage that biology owes to the science of medicine, even though it seems like asking for the impossible.

If you agree with Dr. Thomas, as I do, then we must work harder on the basic research of medicine and on the development of preventive and protective measures to the stresses of the environment experienced by operational aviation. The answers will come more easily, more simply, and with less cost in the long run.

I am confident that (1) if we remember the three R's and the three C's, (2) if we remember the importance of basic research, and (3) if we establish priorities, this meeting will be an outstanding success. I offer you my best wishes for a successful Workshop and I look forward to reading the final report of your labors.

CHAIRMAN'S SUMMARY COMMENTS

Captain Roger G. Ireland, MC, USN
Assistant for Medical & Allied Sciences
Office of the Director, RDTE for the CNO

I would like to express my appreciation to the entire membership of this Technical Workshop for the tremendous efforts made by all to see that our objectives were met and that the Workshop was a success. We successfully convened a distinguished group of experts from the entire country. The attendees were not summoned by a process of random selection; they were selected specifically as representatives from centers of expertise and excellence in the field of Navy aviation medical research support. Only through their attendance and cooperation was there any hope of achieving our objectives.

Among those present at this Workshop were some of the pioneers in naval aviation medicine: men who played significant roles in bringing the Aerospace Medical Specialty to its present state of proficiency. In many instances, these were the men who initially formulated the areas of inquiry with which we continue to deal today. Their comments and suggestions during this Workshop provided a perspective we would not otherwise have achieved. I am grateful for their participation, because they once again have advised us not to "re-invent the wheel."

The majority of attendees were younger flight surgeons, scientists, engineers, and administrators, many of whom were participating in a conference of this type for the first time. These persons represent the group now handling, directly, the problems of R&D management in naval aviation medicine. It was to this group that we looked for new ideas and innovative approaches. Certainly, the objective of this conference was not to review the old problems of bureaucratic management but rather to come up with fresh material. Qur younger members did not disappoint us in this respect and I wish to thank them.

The formal purpose of the Technical Workshop was to review the overall Navy RDT&E program in support of aviation medicine and to make recommendations regarding objectives and priorities for future research. Our mission is to support the Operating Fleet and Marine Corps and the name of the game is still "DEFENSE". Although there have been many recent changes in the military lexicon, that word remains in the Pentagon vocabulary. Our research program must make a significant contribution to our capability and posture of defense.

A less formalized goal of the Workshop was to bring together authorities from both the operational user and RDT&E producer communities and allow them to use this meeting as a forum for a requirements/response dialogue which in turn would lead to research that was responsive to the needs of the Navy. I feel that the week in Charleston, combined with our initial briefing in Washington, was successful in bringing about such a dialogue. As a result, I am optimistic that when the new vehicles and weapons systems now on the drawing board appear in the Fleet, appropriate biomedical support will be at hand. The work done by all four subcommittees is considered to be outstanding.

In reviewing the accomplishments of this Technical Workshop, I would like to comment on two of the problems mentioned in connection with the 1969 Orlando meeting of the Technical Working Group by its Chairman, Captain J.E. Rasmussen. Captain Rasmussen felt that the greatest single obstacle was "that of identifying and analyzing a reasonably complete list of requirements in the area of naval aviation." He was also concerned over the one to two days needed at the beginning of the Orlando meetings to fully indoctrinate all members as to the basic frame of reference being used and the goals of the effort. He felt that attention to these issues cut into the time available for in-depth reviews of R&D program areas.

The difficulties cited by Captain Rasmussen were avoided in this Technical Workshop through the procedure of holding a two-day initial briefing in Washington, D.C. one week prior to the principal meeting in Charleston. These two days provided ample opportunity for briefings by Fleet personnel on forthcoming developments in naval aviation and allowed for a review of procedures to be followed in Charleston. It is strongly recommended that future Technical Workshops follow the same procedure.

I would also like to comment on the selection of a nongovernment site, such as Charleston, S.C., as a locale for holding meetings of this type. In all, although there are a number of costs involved, I consider this workshop to have been a cost-effective bargain for the United States Navy. The Charleston meeting afforded minimal interruptions by telephone and visitor. This would certainly not have been the case at a government facility. As a result, sustained attention was given to the problems at hand and I think this was reflected in the meeting's productivity. Since participants were in travel status, and a captive audience, they tended to continue discussions and to review the topics of the meetings, informally, at mealtime and during other periods of relaxation. These discussions were considered most beneficial. I am convinced that this is a good procedure for the conduct of a "workshop."

Subsequent sections of this report present the recommendations of the four working subcommittees into which the overall membership of the Workshop was divided. These four sections are somewhat different in format. While a standard baseline was given each subcommittee, they were allowed full freedom of expression in describing their results. Subcommittee chairmen felt that the ability to define and alter working procedures as required by their particular content material was necessary to achieve the desired output. The results seem to bear this out.

In closing, I feel that this Technical Workshop was quite successful and I hope that its impact will be reflected in realistic directions and priorities in our research programs of the future. Again, I want to thank each participant for his time and labor. I am most appreciative of the contributions of everyone. The new ideas generated at this Workshop will serve us well in the coming years.

CHAPTER 1

Introduction

The procedures and technology used in naval aviation medicine must remain responsive to the changing needs of the operating air forces. Over a several year period, the extent of change in these needs can be significant. New aircraft are introduced which impose new demands on operators; combat experience dictates the development of new or revised items of personal protective equipment; combat casualties yield data from which treatment procedures are improved; and advances in training technology result in major revisions to training programs.

A vigorous and orderly research and development effort is required in support of naval aviation medicine if it is to keep pace with the changing aviation scene. The present scope of the R&D effort, as represented by laboratory and contractor work units, is in excess of $10 million per year. However, these expenditures are being made at a time when there is constant pressure to reduce funding and personnel assets. For this reason, effective management of R&D resources is a priority requirement for the administrative echelon of aviation medicine in the Navy.

A major step toward comprehensive R&D management was taken when the CNR-CND Technical Working Group on Aviation Biomedical and Behavioral Science Research and Development met in Orlando, Florida, on 24-28 February 1969. This TWG, the first of its kind, was established as one part of a broad program developed by the Headquarters, Naval Material Command (CNM) and the Office of Naval Research (ONR) to provide for more systematic exchange of information in the planning and managing of the Navy's RDT&E program in the Behavioral and Biological Sciences. Members in attendance were drawn from "the user" or operational community, represented by CNO, and non-R&D or technical codes of NAVAIR and BUMED; and from the R&D community, represented by personnel from NAVAIR, BUMED, and ONR Offices sponsoring work in this area. There were also two scientist consultants from Navy laboratories. The purpose of the Orlando TWG was to –

> "establish a procedure to facilitate planning of Navy RDT&E at the program manager level in the Behavioral and Biological Sciences. This procedure will produce improvements in program management through greater coordination, interaction, and flow of information among the program managers of the Behavioral and Biological Sciences and among all pertinent categories of research and development. More specifically, the procedure will provide:
>
> 1. A mechanism for relating ONR, CNM, BUPERS, and BUMED RDT&E programs in the Behavioral and Biological Sciences.

2. A procedure for insuring that specific RDT&E efforts in the Behavioral and Biological Sciences are reviewed as to responsiveness to known requirements.
3. A procedure for integrating ONR, CNM, BUMED, and BUPERS planning and review procedures at the program manager levels in the Behavioral and Biological Sciences.

The coordination/information exchange procedures are not intended to supplant existing programming procedures, directives, organizational structures, or command prerogatives. The intention is to strengthen the information base on which middle management depends for its decisons."

The report of the Orlando meeting reviewed current and projected operational requirements; discussed general administrative problems in RTD&E management; and reviewed specific programs classified in the four topical areas of Clinical Medical Aspects, Psychological Aspects, Personnel Performance, and Life Support. For each of these subgroups, four principal efforts were pursued. First, the broad field of concern was divided into specific problem areas, ranging from three to five such areas per group, and each area was examined in terms of developing broad research objectives considered necessary to carry out effectively the Navy's operational program in aviation medicine. Second, ongoing work units within that field were reviewed as to adequacy and criticality along a number of dimensions and were assigned a priority rating for continuation. Third, presently funded R&D efforts (ongoing work units) were related to the priorities established for research objectives. Finally, specific recommendations for action were made for each of the research objectives identified earlier.

The objectives of the Orlando TWG appear to have been met. Those who participated indicate that it provided an excellent forum for the exchange of information. Program managers in the Navy R&D community have used the report of the meetings to assist in the planning and development of new efforts and report that it was quite useful.

Organization of FY-74 Technical Workshop

Plans for the second in the series of aviation medicine R&D conferences began in early 1972, prompted in part by the successful use of the results of the first meeting and in part by the exigencies of a rapidly changing budgetary support scene. There was a need for a review of operational requirements and for an updating of research priorities. Consequently, it was decided that a second meeting would be held as soon as preparations could be completed but that it would differ in several respects from the earlier conference. First, the meeting was structured as a Technical Workshop rather than a Technical Working Group, with principal support coming from the Bureau of Medicine and Surgery and the Office of Naval Research. Second, the meeting was opened to more individuals representing a broader spectrum of the

R&D community than was the case earlier. Third, inasmuch as some difficulties had been experienced in the Orlando meetings in accomplishing a review of operational requirements documents during the first few days, the present meeting was held in two parts, with an initial two-day session devoted solely to a review of future systems in naval aviation.

The following Navy commands and facilities were represented at the 1973 Technical Workshop:

Office of the Chief of Naval Operations
Office of the Chief of Naval Material
Naval Air Systems Command
Office of Naval Research
Bureau of Medicine and Surgery
Commander, Naval Air Force, Atlantic Fleet
Commander, Naval Air Force, Pacific Fleet
Naval Missile Center
Naval Air Development Center
Naval Aerospace Recovery Facility
Naval Aerospace Medical Institute
Naval Aerospace Medical Research Laboratory
Naval Submarine Medical Research Laboratory
Naval Safety Center

Objectives

The general objective of the Technical Workshop was to review the overall Navy RDT&E program in support of aviation medicine and, in so doing, to provide a forum within which relevant information might be exchanged and in which issues relating to the conduct of RDT&E programs could be discussed. The specific work activities to be accomplished by the Technical Workshop included:

1. *Review of future operational requirements and programs.* Naval aviation medicine must remain responsive to the needs of the operating forces. Therefore, a first objective was to review Navy planning and requirements documents to determine the likely nature of naval aviation in 1980 and beyond. However, since this had proved to be time-consuming during the Orlando meetings, it was decided that the review would be held as a separate meeting, in advance of the main Workshop. The mechanics of accomplishing the review are described in the next section.

2. *Evaluation of ongoing research units.* A second objective of the Technical Workshop was to accomplish a systematic evaluation of all ongoing RDT&E research efforts, as represented by Form 1498 Work Unit descriptions. This evaluation was to serve two purposes. First, coming immediately after the review of projected aviation programs, it should represent a step toward reorientation of the RDT&E program to be more in keeping with future needs. Second, it would provide all attendees with an overview of the scope and direction of current research efforts, thus making more realistic any later recommendations for future research.

3. *Definition of research objectives.* Through consideration of mission requirements and flight characteristics for the coming generation of aircraft, the next step was to specify the research which would be required for aviation medicine to keep pace. This could involve entirely new topics for R&D or a change in the direction of ongoing programs.

4. *Establishment of research priorities.* The final objective was to develop an ordering of recommendations for new research in terms of relative priorities. The priority evaluation took into consideration the relationship of the recommended research to direct mission needs, the adequacy of ongoing research directed toward similar goals, and the extent to which other agencies of the government might already be supporting research of this type.

Operational Requirements Review

The experience in the Orlando meetings of attempting to cull, in a matter of one or two days, information from a large number of planning documents concerning future aviation programs led to consideration of better ways to achieve the same goal. As a result, a program was developed to take advantage of the expertise of Navy personnel in Pentagon planning offices. Interviews were held with a number of key individuals from the following offices:

Aviation Plans and Requirements Division (OP-50),
DCNO (Air Warfare)

Aviation Training Division (OP-59),
DCNO (Air Warfare)

Air Warfare Branch (OP-982),
Office of Research, Development, Test and Evaluation

Atomic Energy Division (OP-985),
Office of Research, Development, Test and Evaluation

Armed Forces Radiobiology Research Institute,
National Naval Medical Center

From these interviews, a report was prepared which describes the advanced technology in prospect for naval aviation systems as well as the biomedical and human effectiveness issues

which those interviewed see as accompanying the new systems. This report is included as Appendix C.

As a second part of the review of advanced technology, all members of the Technical Workshop attended a two-day briefing in Washington on 26 and 27 July 1973. The briefing was held in the Conference Room of the Surgeon General at the Bureau of Medicine and Surgery. The purpose of this classified meeting, referred to colloquially as the "Threat Briefing," was to allow the same planning personnel who had been interviewed earlier to provide an in-depth discussion of advanced aviation systems. The aviation programs report just described, which was distributed to all attendees prior to the meeting, served as a point of departure for the presentations and the ensuing question-and-answer periods. The program followed at this briefing is presented in Appendix A.

Technical Workshop

The Technical Workshop itself was held in Charleston, South Carolina, on 6–10 August 1973. This Workshop consisted of an introductory session, during which the Workshop objectives and general procedures to be followed were reviewed, an extended period for deliberation of R&D issues and for beginning to assemble materials for a Workshop report, and a final summing-up session. For the deliberations, total Workshop membership was divided into four subcommittees, with assignments made according to specific areas of interest. These subcommittees were:

Aviation Operational Medicine
Captain Robert E. Mitchell, MC, USN, Chairman

Physiological Assessment
Captain Laurence H. Blackburn, MC, USN, Chairman

Life Support and Survival Systems
Mr. Dino Mancinelli, Chairman

Human Effectiveness
CDR James E. Goodson, MSC, USN, Chairman

The Workshop was under the general direction of Captain Roger G. Ireland, MC, USN, shown in Figure 1 delivering the welcoming address at Charleston. He was supported by a Steering Committee consisting of:

Captain Robert E. Kinneman, MC, USN
Bureau of Medicine and Surgery

Captain Frank H. Austin, MC, USN
Bureau of Medicine and Surgery

Joseph P. Pollard, M.D.
Office of Naval Research

Arthur B. Callahan, Ph.D.
Office of Naval Research

Mr. Henry A. Fedrizzi
Naval Air Systems Command

Captain Louis R. Kaufman, MSC, USN
Chief of Naval Material

Captain Carl E. Pruett, MC, USN
Bureau of Medicine and Surgery

CDR Paul D. Nelson, MSC, USN
Bureau of Medicine and Surgery

CDR Horace J. Connery, MSC, USN
Chief of Naval Operations

Each subcommittee prepared a report presenting conclusions relating to its specialized field of interest. Although the Steering Committee suggested a general format to be followed by subcommittees during their deliberations and in the preparation of their conclusions, considerable latitude was allowed in the interest of effectiveness. The next four sections of this report present the results and recommendations achieved through the efforts of the four subcommittees.

Figure 1. Captain Roger G. Ireland addressing Technical Workshop at opening of Charleston meeting.

CHAPTER 2

Aviation Operational Medicine

Captain Robert E. Mitchell, MC, USN, Chairman

The name of our subcommittee is Aviation Operational Medicine. As some of you know, I feel very strongly about the term "operational" because I think there has been too great a tendency over the past few years to have everything go to the hospitals. I think people have forgotten that the reason for the United States Navy Medical Department is support of the operational Fleet. Although I realize that we have to take care of dependents and such, I think there has been too much emphasis on this aspect and too little on the fact that we have a Fleet to look after.

During the early part of this meeting, some questions were raised as to why we were reviewing the old 1498s, why it was necessary to review projects already underway, especially since we were well into the fiscal year. I think we have found the review to be extremely valuable. First of all, *I* was not completely aware of work being done throughout the Navy in the areas of operational aviation medicine. The review gave me some insight into that, and I think it also gave other members of the committee some insight. Secondly, although we are well into this fiscal year, I think reviewing the 1498s gave us an opportunity to decide whether some of these projects really should be continued. As it happens, we came up with quite a few that we felt had no relevance to aviation medicine, and, in some cases, had no relevance to the Navy at all.

We did go through all the 1498s, and I think we have come up with quite a realistic summary as well as recommendations on continuing or ending some programs in the future. As far as new work is concerned, there is one area which is very important: we need some quick-and-dirty techniques to determine pilot fitness for flight. When you talk to a pilot, you do not really get the information you need; in fact, he may even be covering up some information you would like. There should be something in the way of a biochemical technique which could be carried out aboard a carrier or at a Naval Air Station and which would tell us in a matter of minutes where the man stands.

There is one project now underway which relates to the biochemical technique we need. The one I mean is being carried out up at Dr. Blackburn's laboratory at NADC using just urine. It is a noninvasive technique to determine stress in an individual.

We also need to know more about the physical fitness of pilots and aircrew. We do a lot of talking about physical fitness, and people keep coming up with programs – hundred yard

dashes and that sort of thing – to keep the individual fit. But so far as I know, and I think the committee agrees, there is no definition of physical fitness. We really need to set down some standards in this area, especially since we are now taking on females as aircrew as well as men. Not only do we not have standards for females, but we do not even have them for males. What degree of physical fitness does a man have to have, for example, to fly an airplane or a given type of airplane? We need to look into this.

Another area of interest to us is the status of the Prisoner of War aviators. The long-term health of these individuals is, I think, going to be very interesting. I question whether this is research, but I think it is worth a look.

Still another need, and we have been proposing this for years, is a data bank which would tell us, for example, how many pilots wear glasses. I mention glasses, but actually the information in the data bank could refer to any particular physical finding or any illness which might be of interest to the Bureau for setting physical standards and that sort of thing.

We also discussed the LAMPS-type activity which requires pilots to be away from a central medical facility, possibily for long periods of time. How are we to look after these pilots or the aircrews assigned to these units? This is an area which needs investigation.

At Pensacola, and in many of the other laboratories, there are research programs going on which use human subjects. After these programs end, who is going to follow through on these people to see what happens to them over a period of years? We feel there is a need for a project in this particular area.

I think that just about covers my report. We came up with nine new areas of study which are presented in the remainder of this section.

NEW RESEARCH NEEDS

Code No. AOM-1 **Problem Area(s)** Performance and Selection; Clinical Medicine/Physical Fitness

New Requirement Longitudinal study of POWs/Naval aircrew personnel.

Comments: The physical fitness of the POWs to return to flight status should be determined.

Development Category 6.1 **Level of Effort** A

Code No. AOM-2 **Problem Area(s)** Special Senses; Performance and Selection

New Requirement Longitudinal study of naval helicopter aircrews.

Comments: There is a need to know the effects of stress, vibration, and noise on aircrew.

Development Category 6.1 **Level of Effort** A

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. AOM-3 **Problem Area(s)** Clinical Medicine/Physical Fitness

New Requirement Development of aviation physical qualifications data bank to provide rapid retrieval of pertinent aircrew data.

Comments: There is need for baseline data on pilots and air flight personnel to validate present physical standards. An automated annual physical is one suggestion.

Development Category 6.1 **Level of Effort** B

Code No. AOM-4 **Problem Area(s)** Special Senses; Performance and Selection

New Requirement Investigation of motion sickness relative to FLIR-optically induced motion sickness.

Comments: There should be an alert to this problem area.

Development Category 6.1 **Level of Effort** B

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. AOM-5 **Problem Area(s)** Clinical Medicine/Physical Fitness

New Requirement Definition for standards of physical fitness in aircrew personnel.

Comments: There is need to develop some physical fitness standards for male and female personnel in flight training, operational and carrier fields.

Development Category 6.1 **Level of Effort** A

Code No. AOM-6 **Problem Area(s)** Performance and Selection; Stress Physiology/Combined Stress; Clinical Medicine/Physical Fitness

New Requirement Biomedical predictors of performance decrement factors in Naval aviation.

Comments: There is need for a study to determine the biomedical predictors of fatigue levels leading to performance decrement. We continue to develop ultra high performance aircraft with long range requirements, long duration flights. There is need to quantify fatigue.

Development Category 6.1 **Level of Effort** B

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. AOM-7 **Problem Area(s)** Clinical Medicine/Physical Fitness

New Requirement Audiovisual medical communications to provide flight surgeon for LAMPS, ships, aircrews.

Comments: There is need for an audiovisual communications system between LAMPS, vessels, and a central medical facility. Isolation of LAMPS vessels will require medical coverage for aircrew who are attached to LAMPS vessels. A secondary utilization would be medical care of other personnel aboard vessels.

Development Category 6.1 **Level of Effort** B

Code No. AOM-8 **Problem Area(s)** Clinical Medicine/Physical Fitness

New Requirement Longitudinal followup of human research subjects.

Comments: No provision has been made for long-term followup of research subjects. The anticipated cost per year would be less than $25K, probably about $15K.

Development Category 6.2 **Level of Effort** A

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

Aviation Operational Medicine

Subcommittee

NEW RESEARCH NEEDS

Code No. AOM-9 **Problem Area(s)** Clinical Medicine/Physical Fitness

New Requirement Development of noninvasive technique to detect prodromes of acute disease in aviators.

Comments: There is no information in this area and there is a need for it. The present capability is nonexistent.

Development Category 6.1 **Level of Effort** B

Code No. **Problem Area(s)**

New Requirement

Comments:

Development Category **Level of Effort**

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

CHAPTER 3

Physiological Assessment

Captain Laurence H. Blackburn, MC, USN, Chairman

The increased capabilities of future fighter, attack, helicopter, and patrol aircraft programs have an almost direct effect on the physiological demands made on crewmen assigned to these aircraft. The Physiological Assessment Subcommittee feels, consequently, that there are three very critical requirements within our assigned area of responsibility:

1. Biomedical assessment of environmental stresses, both singly and in combination, to be conducted in such a manner as to reflect realistically the actual operating environment of aircrews. The results and conclusions must be presented in such a format as to represent all crew systems disciplines, including life sciences, human factors, and, especially, the engineering disciplines. These data must then be utilized in the design specifications which are necessary to develop procedures and equipment required to protect the aircrewman or to help him adapt to the hazardous environment in which he operates.

2. Operationally realistic assessments of biomedical adequacy and safety of life support systems and other protective measures developed for aircrewmen.

3. More thorough analyses and better dissemination of the physiological information and data currently available so that these data can be applied more usefully to biomedical design specifications, criteria, and protective or adaptive measures.

To those of you who were at Orlando four years ago, these words are only slightly changed, really, from the statements made in your report in this area. The significant differences are only in a matter of degree and relative priority. I do not mean to exaggerate the wisdom of the group in 1969 or to minimize the wisdom of my able group here in 1973; I feel these are the facts, loud and clear. We do not have, in either quality or quantity, nearly the amount of realistic operational data necessary to assess adequately the physiological performance decrements of the environmental stresses present in aviation. We do not have nearly enough data to establish adequate design specifications or criteria for developing protection against environmental hazards or to evaluate realistically measures and equipment for biomedical adequacy and safety. I repeated myself purposely here, because there are, in the rather applied area of crew systems we are being presented with these days, tremendous opportunities to improve the effectiveness of the man in the system and his capabilities. Consequently, I feel we must do a more credible job in the area of operationally realistic aircrew and biomedical assessment, protection, and adaptation, or we will be left behind in the dust. Our credibility with our operational forces will become zero, and we will have mostly ourselves to blame.

In making its report, this subcommittee listed physiological requirements associated with present and future aircraft systems. To aid in isolating specific problem areas, the flight scenario was divided into four phases: Normal Inflight; Emergency Inflight and Impact; Emergency Egress and Recovery; and Survival and Rescue. Within each of these phases, many unique requirements to specific problem areas were outlined in detail. It might be advantageous to the reader, however, if we summarized what we considered to be the most important issues associated with each of these flight phases.

1. *Normal Inflight*

   a. VA/VF aircraft now under design will require aircrew tolerance of much higher G levels than do current aircraft. Current methods of G protection appear to be totally inadequate to ensure such protection. New and novel ways to provide G protection at higher levels must be investigated and developed.

   b. V/STOL aircraft incorporating vectored thrust introduce new mechanical force problems to the aircrew. Investigations must be made to determine the tolerance limits to the lateral G and multi-axis G forces present in such aircraft, and protective measures/equipment developed and evaluated.

   c. Optical display devices now under development require the derivation of criteria for the visual characteristics of such systems, and an operationally realistic evaluation of their effectiveness.

   d. Up-to-date *functional* anthropometry tables are required to ensure proper sizing tables for equipment procurement and adequate criteria for the design of advanced crew stations to maximize man/machine interface effectiveness.

   e. Weapons systems involving BW/CW agents and lasers are under development. Exposure tolerances and protective equipment design criteria are needed to ensure adequate crewman effectiveness when exposed to such systems.

   f. Biomedical and performance assessments must be made of environmental hazards under operationally realistic conditions, singly or in combination. Biomedical adequacy and safety of protective/adaptive equipment must likewise be assessed, and measures developed to protect against environmental hazards.

2. *Emergency Inflight and Impact*

   a. Analysis of human dynamic response to impact, and translation of these data into design specifications and criteria for the engineering development of protective equipment, are necessary.

b. Anthropomorphic dummies that more closely resemble human responses are required for impact protection equipment testing at levels where it is unsafe to use human volunteers.

3. *Emergency Egress and Recovery*

   a. Definition of the entire biodynamic envelope of escape systems, including the latest engineering developments in this field (modules, extraction systems), is required.

   b. As with impact, there should be development of a more accurate human analog dummy for use in impact/emergency egress/recovery biomedical assessment situations where forces involved prohibit use of human volunteers and where design parameters are needed as to acceptability of forces that may cause reversible versus irreversible injury and/or compromise in later survival/rescue/evasion phases.

   c. Functional anthropometry is necessary, as with every other area.

   d. Development of acceptable biomedical criteria for maneuvering parachutes, air-to-air and air-to-ground recovery, and various "flyaway" seats or modules has been made necessary by new requirements from Southeast Asia and new engineering concepts.

4. *Survival and Rescue*

   a. There should be an accumulation of the basic physiological data necessary for survival; these data should take into account the relative role of various portions of the body in temperature regulation and heat loss.

   b. Derivation of biomedical design specifications and criteria is needed for passive and active methods of protection from cold.

   c. Biomedical assessment of the adequacy of current survival equipment is needed.

   d. Review of much of the physiological data now available for applicability in deriving design specifications and criteria should be undertaken.

   e. Definition should be made of thermal and other survival aspects of new concepts of escape/survival systems, including crew modules.

AVIATION MEDICINE REQUIREMENTS ANALYSIS

Normal Inflight

Subcommittee **Physiological Assessment**

Problem Area	Unique Requirements	Related Ongoing Efforts			Present Work				
		1498 Code No.	Location	Priority Level*	Completely Adequate	Partially Adequate	Related Only Minimally	No R & D Required	New Research Code**
Mechanical Force Environment (VA & VF only)	1. Devise better methods to increase tolerance to acceleration:								
	A. Drugs								PA-1
	B. Positioning	150	NADC	4		X			PA-2
	C. Preconditioning	215	NAMRL	2		X			PA-1
		040	HOPKINS	N.A.			X		
	D. Breathing maneuvers							X	
	E. Negative and lateral "G"	228	NAMRL	3		X			PA-3
	F. Protective equipment	139	NADC	4	X				
Mechanical Force Environment (VA, VF, VP & VS)	2. Devise better methods to determine tolerance to buffeting:								
	A. Center of gravity determinations on head and impact tolerances for various parts of head	235	NADC	3	X				PA-4
	B. Protective equipment	139	NADC	4	X				
Mechanical Force Environment (Helo)	1. Biomedical assessment of vibration in the helicopter environment.	146	NADC	4		X			PA-12
Special Senses (All A/C)	1. Disorientation, training and selection requirements.								PA-5
	2. Display devices, visual criteria.								PA-6

*Priority Level

4 = Continue vigorously, possibly at increased level.
3 = Continue at current level.
2 = Continue at present level; review for termination later.
1 = Terminate.

**See New Research Needs.

AVIATION MEDICINE REQUIREMENTS ANALYSIS

Normal Inflight Subcommittee **Physiological Assessment**

Problem Area	Unique Requirements	Related Ongoing Efforts			Present Work				
		1498 Code No.	Location	Priority Level*	Completely Adequate	Partially Adequate	Related Only Minimally	No R & D Required	New Research Code**
Special Senses (VP/VS)	1. Motion sickness.	205	NAMRL	2		X			
Special Senses (Helo)	1. Biomedical assessment of disorientation in flicker vertigo and visual tracking.	008	NRC	N.A.			X		PA-13
		213	NAMRL	3		X			
Performance and Selection (All A/C)	1. Functional anthropometry.								PA-7
	2. Biomedical predictors of stress reaction.	022	STANFORD	N.A.			X		
		144	NADC	3		X			PA-8
		048	HUMFACT	1			X		
		016	STANFORD				X		
		047	HARBOR HOSPITAL				X		
Thermal/Climatic (All A/C)	1. Determine acceptable temperature ranges. Define physiological and performance decrement associated with ranges.								PA-14
Altitude (VA, VF, VP & VS)	1. Determination of optimum breathing environment for shirtsleeve environment module.	021	A. EINSTEIN	N.A.			X		
		142	NADC	4	X				
		128	NADC	N.A.			X		
Altitude (All A/C)	1. Protective equipment.	139	NADC	4	X				

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**See New Research Needs.

AVIATION MEDICINE REQUIREMENTS ANALYSIS

Normal Inflight

Subcommittee **Physiological Assessment**

Problem Area	Unique Requirements	Related Ongoing Efforts: 1498 Code No.	Related Ongoing Efforts: Location	Related Ongoing Efforts: Priority Level*	Present Work: Completely Adequate	Present Work: Partially Adequate	Present Work: Related Only Minimally	Present Work: No R & D Required	New Research Code**
Altitude (All A/C)	1. Determination of low grade hypoxia and effects of toxicants (CO).								PA-15
Stress Physiology/ Combined Stress (All A/C)	1. Determination of the synergistic and antagonistic effects of combined stresses under operationally realistic conditions including acceleration, vibration/buffeting, altitude, temperature, noise, lighting, task loading, and radiation.	001	NYU	3		X			
		148	NADC	3		X			
		237	NADC	4		X			
		146	NADC	4		X			
		013	U. ILL.	N.A.		X			
		223	NAMRL			X			
		206	NAMRL	3		X			
		202	NAMRL	4		X			
		140	NADC	4			X		
		149	NADC	4			X		
		026	U. FLOR.	N.A.			X		
		031	U. PITTS.	N.A.		X			
	2. Protective equipment design criteria and evaluation.	139	NADC	4	X				
	3. Long-term effects of combined stress.								PA-9
Radiation/Toxicology (All A/C)	1. Biomedical assessment of hazards from special weapons BW/CW, nonionizing radiation, and lasers.	012	U. PA.	2.5			X		
		042	U. WASH.	2.5		X			PA-10
		141	NADC	2	X				
		152	NADC	4		X			

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**See New Research Needs.

AVIATION MEDICINE REQUIREMENTS ANALYSIS

Normal Inflight Subcommittee **Physiological Assessment**

Problem Area	Unique Requirements	Related Ongoing Efforts			Present Work				
		1498 Code No.	Location	Priority Level*	Completely Adequate	Partially Adequate	Related Only Minimally	No R & D Required	New Research Code**
	2. Protective equipment design criteria and evaluation.	028	BATTELLE	3		X			
		220	NAMRL	4		X			
		143	NADC	2		X			
		004	VACOMU	2		X			
		139	NADC	4	X				
		165	NADC	3	X				
Accident Prevention (All A/C)	1. Determinations of mechanisms in (and definition of) neurophysiological fatigue.	001	NYU	1			X		
		013	U. PITTS.	N.A.			X		
		017	PURDUE	N.A.			X		
		022	STANFORD	N.A.			X		PA-11
		047	HAR. HOSP.	1		X			
		048	HUMFACT	1		X			
		144	NADC	3		X			
		146	NADC	4		X			
		148	NADC	3		X			
		237	NADC	4		X			

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**See New Research Needs.

AVIATION MEDICINE REQUIREMENTS ANALYSIS

Emergency Inflight and Impact

Subcommittee Physiological Assessment

Problem Area	Unique Requirements	Related Ongoing Efforts: 1498 Code No.	Location	Priority Level*	Present Work: Completely Adequate	Partially Adequate	Related Only Minimally	No R & D Required	New Research Code**
Mechanical Force Environment (All A/C)	1. Determination of human dynamic response to impact acceleration.	227 235	NAMRL NADC	4 3	X 	 X			
	2. Physiological assessment and evaluation of crew protective and restraint systems.	139 140	NADC NADC	4 4	X 	 X			
	3. Physiological criteria for the development of improved anthropomorphic dummies used for impact testing.								PA-16
	4. Physiological criteria for the delethalization of crew stations.	235	NADC	3		X			PA-17
Special Senses (All A/C)	1. Evaluation of sensory modalities for emergency warning indices.								PA-18
	2. Monitoring and correction of the state of pilot alertness by feedback.								PA-19
Performance and Selection (All A/C)	1. Functional anthropometry.								PA-20
Altitude (All A/C)	1. To establish criteria for a shirtsleeve cabin atmosphere of gases and pressures which would be safe during decompression	142 013 043	NADC U. ILL. U. MICH.	4 N.A. N.A.	X 				

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1 = Terminate.

**See New Research Needs.

AVIATION MEDICINE REQUIREMENTS ANALYSIS

Emergency Inflight and Impact Subcommittee **Physiological Assessment**

Problem Area	Unique Requirements	Related Ongoing Efforts			Present Work				
		1498 Code No.	Location	Priority Level*	Completely Adequate	Partially Adequate	Related Only Minimally	No R & D Required	New Research Code**
	2. Biomedical evaluation of adequacy of oxygen masks under high respiratory workload conditions.	149	NADC	4	X				
Radiation/Toxicology (All A/C)	1. Biomedical assessment of toxicants from combustion of materials used in aircraft cabins and in personal equipment and clothing.	165 140	NADC NADC	3 4			X X		PA-21
	2. Biomedical prevention and protection design specifications and criteria from inflight and impact fires.	165 140	NADC NADC	3 4	X X				
	3. Toxicology of (new) fire suppressants for use in aircraft cabin environments.	165	NADC				X		PA-22

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**See New Research Needs.

AVIATION MEDICINE REQUIREMENTS ANALYSIS

Emergency Egress and Recovery Subcommittee **Physiological Assessment**

Problem Area	Unique Requirements	Related Ongoing Efforts			Present Work				
		1498 Code No.	Location	Priority Level*	Completely Adequate	Partially Adequate	Related Only Minimally	No R & D Required	New Research Code**
Mechanical Force Environment (All A/C)	1. Reevaluate tolerable limits of the biodynamic envelope of escape systems (ejection seats, modules, extraction systems) including the use of positioning devices.	137	NARF	3.5			X		PA-23
		227	NAMRL	4		X			
		139	NADC	4		X			
	2. Evaluate the relationship between peak G and rate of onset of G of escape systems.	227	NAMRL	4		X			PA-23
		139	NADC	4			X		
		137	NARF	3.5		X			
	3. Determine human tolerance levels for angular rotation of rotating escape systems and for vertical seeking systems in ejection seats, modules.	139	NADC	4		X	X		PA-23
		137	NARF	3.5			X		
	4. Define the biodynamic envelope of windblast.								PA-23
	5. Establish biodynamic envelope for human exposure to parachute opening shock and deceleration.	136	NARF	3			X		PA-25
		137	NARF	3.5			X		
		135	NARF	3.5			X		
	6. Develop a better human analog for test and evaluation purposes, i.e., a dummy that simulates a human better.								PA-26

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1 = Terminate.

**See New Research Needs.

AVIATION MEDICINE REQUIREMENTS ANALYSIS

Emergency Egress and Recovery — Subcommittee: Physiological Assessment

Problem Area	Unique Requirements	Related Ongoing Efforts: 1498 Code No.	Related Ongoing Efforts: Location	Related Ongoing Efforts: Priority Level*	Present Work: Completely Adequate	Present Work: Partially Adequate	Present Work: Related Only Minimally	Present Work: No R & D Required	Present Work: New Research Code**
Mechanical Force Environment (All A/C)	7. Establish a quantitative comparison between dummy and human response to parachute opening shock force.	136	NARF	3		X			PA-27
		135	NARF	3.5			X		
		137	NARF	3.5		X			
		227	NAMRL	4		X			
	8. Develop and establish acceptance criteria for parachute oscillations and maneuvering.	136	NARF	3		X			PA-28
Personnel and Selection (All A/C)	1. New sizing table for life support equipment and restraint systems based on functional anthropometry are required.	139	NADC	4			X		PA-29
	2. Need for a predictive longitudinal study for anthropometry.								PA-29
Thermal (All A/C)	1. Biomedical design specifications and criteria for protection from fires and evaluation of adequacy of protection.	140	NADC	4		X			
		165	NADC	3		X			
Special Senses (VA, VF, V/STOL & VS)	1. Establish biodynamic envelope of vertical-seeking escape system.								PA-24

*Priority Level

4 = Continue vigorously, possibly at increased level.
3 = Continue at current level.
2 = Continue at present level; review for termination later.
1 = Terminate.

**See New Research Needs.

AVIATION MEDICINE REQUIREMENTS ANALYSIS

Emergency Egress and Recovery Subcommittee **Physiological Assessment**

Problem Area	Unique Requirements	Related Ongoing Efforts			Present Work				
		1498 Code No.	Location	Priority Level*	Completely Adequate	Partially Adequate	Related Only Minimally	No R & D Required	New Research Code**
Combined Stress (All A/C)	1. Determination of acceptable physiologic envelope for escape systems from ejection to impact.	227	NAMRL	4		X			PA-23
		136	NARF	3			X		
		137	NARF	3.5			X		
		235	NADC	3			X		
	2. Definition of tolerance to noise and overpressure from explosive activations systems.								PA-30

*Priority Level

4 = Continue vigorously, possibly at increased level.
3 = Continue at current level.
2 = Continue at present level; review for termination later.
1 = Terminate.

**See New Research Needs.

AVIATION MEDICINE REQUIREMENTS ANALYSIS

Survival and Rescue Subcommittee **Physiological Assessment**

Problem Area	Unique Requirements	Related Ongoing Efforts			Present Work				
		1498 Code No.	Location	Priority Level*	Completely Adequate	Partially Adequate	Related Only Minimally	No R & D Required	New Research Code**
Mechanical Force Environment (All A/C)	1. Evaluate biodynamic forces in air-to-air rescue.								PA-31
Special Senses (All A/C)	1. Motion sickness in life raft.								PA-32
Thermal/Climatic (All A/C)	1. Minimization of heat loss from hands and feet.	138	NADC	4		X			PA-33
	2. Develop means of protection from an adaption to extreme thermal environments.	144	NADC	3		X			
		031	U. PITTS.	N.A.			X		PA-34
		138	NADC	4		X			
		001	NYU	1			X		
		027	U. WISC.	N.A.			X		PA-36
		020	U. HOUST.	N.A.			X		
		039	U. CALG.	1		X			
		017	PURDUE	N.A.			X		
		026	U. FLOR.	2			X		
	3. Biomedical assessment of adequacy of current survival equipment.								PA-35

*Priority Level

4 = Continue vigorously, possibly at increased level.
3 = Continue at current level.
2 = Continue at present level; review for termination later.
1 = Terminate.

**See New Research Needs.

AVIATION MEDICINE REQUIREMENTS ANALYSIS

Survival and Rescue Subcommittee **Physiological Assessment**

Problem Area	Unique Requirements	Related Ongoing Efforts			Present Work				
		1498 Code No.	Location	Priority Level*	Completely Adequate	Partially Adequate	Related Only Minimally	No R & D Required	New Research Code**
Clinical Medicine/ Physical Fitness (All A/C)	None	047	HARBOR HOSPITAL	1			X		

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1 = Terminate.

**See New Research Needs.

NEW RESEARCH NEEDS

Code No. PA-1 **Problem Area(s)** Mechanical Force Environment

New Requirement Devise better methods to increase G tolerance artificially.

Comments: Training aids and protective equipment have lagged behind progress of high performance aircraft. A review of available data and of work now being done, and new initiatives in research are needed to determine whether drugs, preconditioning, and breathing maneuvers, or combinations of these, can significantly improve G tolerance.

Development Category 6.1, 6.2 **Level of Effort** A

Code No. PA-2 **Problem Area(s)** Mechanical Force Environment

New Requirement Develop design specifications and criteria for a high G body positioning system that is compatible with future VA/VF aircraft.

Comments: Different body positioning approaches have been tried as a solution to better tolerance of high G forces. Evaluation of data from these experiments, as to effectiveness, and the translation of these data into design specifications, must be mated with engineering requirements to ensure that an effective system is designed for a specific aircraft of the future.

Development Category 6.3 **Level of Effort** A

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-3 **Problem Area(s)** Mechanical Force Environment

New Requirement Assess negative and lateral G forces with respect to their effects (tolerances to and means of protection from G forces).

Comments: Recent emphasis in negative and lateral G force studies must provide a proper impetus to devising/designing preconditioning restraint systems and/or protective systems. Future V/STOL aircraft will have much greater vectored thrust than do current aircraft.

Development Category 6.2 **Level of Effort** A

Code No. PA-4 **Problem Area(s)** Mechanical Force Environment; Stress Physiology/Combined Stress

New Requirement Determine CG of the human head and changes thereto when wearing protective helmet assemblies.

Comments: Protective helmets and attached subsystems (components) all have added to the weight and shift of CG. This has resulted in increased fatigue and has compromised peripheral vision. It has also affected scanning patterns.

Development Category 6.2 **Level of Effort** B

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-5 **Problem Area(s)** Special Senses

New Requirement Devise a system to determine individual susceptibility to disorientation to be used in selection and training of aircrewmen.

Comments: A screening procedure is needed to preselect applicants for the various aviation training programs. A study of this type may lead to better training techniques and devices which can be implemented in the training syllabi of aircrewmen.

Development Category 6.2 **Level of Effort** B

Code No. PA-6 **Problem Area(s)** Special Senses

New Requirement Display device visual criteria.

Comments: New developments in electronic and optical technology have produced a new class of display devices such as virtual image displays, cathode ray tube crew-mounted displays and holographic displays. The criteria for the visual characteristics of such devices have not been determined. The proposed effort is intended to determine the visual criteria and make these criteria available to physical scientists and engineers in a usable form.

Development Category 6.1 **Level of Effort** A

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-7 **Problem Area(s)** Performance and Selection

New Requirement Functional anthropometry of naval aircrewmen.

Comments: Current functional anthropometry is required for use by aircraft workspace designers and by designers of aircrewmen's protective clothing and equipment in order to improve man-machine compatibility.

Development Category 6.3 **Level of Effort** A

Code No. PA-8 **Problem Area(s)** Performance and Selection

New Requirement Physiological/biochemical predictors to determine stress reactions.

Comments: Predictors related to stress reactions in the aviation environment are needed for use in preselection of aircrewmen. The ability to recognize, on a real-time basis, exposure to stress which might degrade or make unsafe further mission flights is the objective of this study.

Development Category 6.2 **Level of Effort** B

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-9 **Problem Area(s)** Stress Physiology/Combined Stress

New Requirement Determine long-term effects of combined stresses in aviation.

Comments: Longitudinal studies on effects of combined stress would provide valuable data that could be used in the design of aircraft, equipment, training, flight profiles, task loading, etc.

Development Category 6.2 **Level of Effort** B

Code No. PA-10 **Problem Area(s)** Radiation/Toxicology

New Requirement Biomedical assessment of hazards from BW/CW and lasers.

Comments: With continued introduction of sophisticated weapons systems in aviation, there is a need to define safe distances and exposures at various workspaces, and to develop protective equipment where required.

Development Category 6.2 **Level of Effort** A

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-11 **Problem Area(s)** Accident Prevention

New Requirement Determination of mechanisms and definition of neurophysiological fatigue.

Comments: A more complete understanding of the basic mechanisms of fatigue on a neurohumeral basis is required, in order to develop adequate adaptive/protective measures for aircrews in highly stressful missions.

Development Category 6.1 **Level of Effort** B

Code No. PA-12 **Problem Area(s)** Mechanical Force Environment; Stress Physiology/Combined Stress

New Requirement Biomedical assessment of vibrations in the helicopter operational environment.

Comments: Physiological/performance degradation in operational helicopter environments, due to vibration and other environmental stresses, has never been determined under operational conditions. This is required in order to develop adaptive/protective measures to optimize aircrew capability to perform their mission.

Development Category 6.2 **Level of Effort** B

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-13 **Problem Area(s)** Special Senses

New Requirement Biomedical assessment of disorientation in helicopter operational environment.

Comments: There is a need to investigate cause, effect, amplitude, etc. of flicker vertigo, visual tracking problems, etc. The data can be applied to implementation of training techniques and may also be used in selection of helicopter personnel and in the development of adaptive/protective measures.

Development Category 6.1 **Level of Effort** B

Code No. PA-14 **Problem Area(s)** Thermal/Climatic; Stress Physiology/Combined Stress

New Requirement Determination of acceptable ranges of temperature for hot and cold temperature conditions.

Comments: Physiological and performance decrements related to aircrews having to operate in extreme hot/cold temperature conditions should be defined, and temperature tolerance limits developed for such aircrews which will ensure their maximum operational effectiveness.

Development Category 6.2 **Level of Effort** B

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-15 **Problem Area(s)** Altitude; Clinical Medicine/Physical Fitness

New Requirement Investigate threat of low grade hypoxia and toxicants in aviation operational environment.

Comments: There is danger of low grade hypoxia and toxicants when flying at altitudes around 10,000 feet, especially for long duration flights such as those in the LAMPS and P-3 (VP/VS) Programs.

Development Category 6.2 **Level of Effort** B

Code No. PA-16 **Problem Area(s)** Mechanical Force Environment

New Requirement Physiological criteria for development of significantly improved anthropomorphic dummies for input testing.

Comments: Impact tests with humans are restricted to force levels which are not expected to produce injury. Testing of impact protective systems should include force levels where injury is probable. Experimentation with nonhuman primates cannot necessarily be extrapolated to man because of differences in size, posture and anatomical structures. For testing the grey areas between reversible and irreversible injury, including death, an anthropomorphic "Superdummy" is needed.

Development Category 6.2 **Level of Effort** A

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-17 **Problem Area(s)** Mechanical Force Environment

New Requirement Physiological criteria for the delethalization of crew stations.

Comments: Crewmember injury during crash landing is often caused or compounded by the structural configuration of the crew station. Many energy-absorbing systems are now available and it is important to define the physiological criteria for the use of such systems. Inflatable devices which delethalize selected portions of the crew station appear to be especially beneficial.

Development Category 6.2 **Level of Effort** B

Code No. PA-18 **Problem Area(s)** Special Senses

New Requirement Evaluation of sensory modalities for emergency warning indices.

Comments: Sight and sound are saturated sensory areas in the cockpit. Tactile senses should be investigated for the use of emergency warning indices.

Development Category 6.1 **Level of Effort** B

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-19 **Problem Area(s)** Special Senses

New Requirement Monitoring and correction of the state of pilot alertness by feedback.

Comments: The pilot and crew are the only system in the aircraft not currently monitored. The state of alertness of the pilot could be monitored through EEG, etc. with feedback given to him. Use of tactile stimulation for this feedback should be considered. Much of the basic work for this has already been done.

Development Category 6.1 **Level of Effort** B

Code No. PA-20 **Problem Area(s)** Performance and Selection

New Requirement Functional anthropometry.

Comments: Current cockpit design and life support equipment is based upon anthropometric data obtained many years ago. Furthermore, restraints of movement in many cockpits, especially VA/VF, make measurement of the man in an ordinary chair useless without some factor of correlation. Acceptance of female and foreign national trainees makes this study of increased importance.

Development Category 6.2 **Level of Effort** A

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-21 **Problem Area(s)** Radiation/Toxicology

New Requirement Biomedical assessment of toxicants from combustion of materials used in aircraft cabins and in personal equipment and clothing.

Comments: As new materials are developed and used in cockpits and for personal equipment and clothing, they should be evaluated for their toxic potential from combustion.

Development Category 6.2 **Level of Effort** B

Code No. PA-22 **Problem Area(s)** Radiation/Toxicology

New Requirement Toxicology of new fire suppressants for use in aircraft cabin environments.

Comments: As new fire suppressant materials (gases, powders, liquids, etc.) become available, they should be evaluated for toxicity.

Development Category 6.3 **Level of Effort** B

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-23 **Problem Area(s)** Mechanical Force Environment

New Requirement Determine and define the safe, feasible biodynamic envelope for escape systems (ejection seats, modules/capsules, and helicopter escape systems).

Comments: A coordinated program must be initiated to: (1) analyze currently available data; (2) integrate results of current partially adequate programs; (3) derive basic research data in areas where (1) and (2) are not applicable in order to define the biodynamic escape envelope for escape systems.

Development Category 6.1, 6.2 **Level of Effort** A

Code No. PA-24 **Problem Area(s)** Mechanical Force Environment; Survival/Rescue/Flotation

New Requirement Determination of human tolerance levels for combined angular/linear rotation of rotating/vertical seeking escape systems.

Comments: Proposed escape systems may contain a sensing system to orient the seat/module to vertical quickly when the escape system is activated in a low-level unusual attitude. Biodynamic data are required to determine the tolerable level of such rotation so that a system can be designed which will be within human tolerance limits.

Development Category 6.1 **Level of Effort** B

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-25 **Problem Area(s)** Mechanical Force Environment; Survival/Rescue/Flotation

New Requirement Establish biodynamic envelope for human exposure to parachute opening shock. Set tolerance limits to parachute opening shock type +Gz.

Comments: The developmental aim of many new escape systems is to decrease time from ejection to fully opened parachute. The devices which have been invented to do this have increased parachute opening shock. Military standard and specification documents do not present design criteria relative to opening shock force. Some current Navy ejection system parachutes appear to be near the human tolerance to parachute opening shock.

Development Category 6.2 **Level of Effort** A

Code No. PA-26 **Problem Area(s)** Mechanical Force Environment; Survival/Rescue/Flotation; Accident Prevention

New Requirement Develop a better human analog (i.e., test dummy) for RDT & E purposes.

Comments: State-of-the-art test dummies capable of transmitting many channels of force-field data are relatively poor analogs of man from the anthropometric and anatomic/physiologic standpoints.

Development Category 6.3 **Level of Effort** A

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-27 **Problem Area(s)** Mechanical Force Environment; Accident Prevention; Survival/Rescue/Flotation

New Requirement Establish quantitative comparisons between test dummy and human subject response to parachute opening shock and landing impact forces.

Comments: Test dummies are used in final acceptance of ejection seat escape systems. Recovery system engineers do not have available comparison data between test dummies and human subjects. These data are required in MIL-STD-858.

Development Category 6.2 **Level of Effort** B

Code No. PA-28 **Problem Area(s)** Mechanical Force Environment; Survival/Rescue/Flotation

New Requirement Develop and establish acceptance criteria for parachute oscillations and steerability (maneuvering).

Comments: Combat ejectees state they require a steerable parachute canopy for escape from the enemy and for selection of landing spot. They also need a parachute which oscillates less than the current Fleet emergency egress canopy. Motion sickness induced by oscillations may be extremely severe – enough to compromise the survival of an injured/stressed aircrewmember.

Development Category 6.2, 6.3 **Level of Effort** A

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-29 **Problem Area(s)** Performance and Selection

New Requirement Determine sizing table for ejection seat/extraction escape systems based on operationally realistic functional anthropometry.

Comments: Functional anthropometry measurements for new sizing tables must be obtained in order to ensure compatibility between the crewman sizing and the design of the escape system, including the seat, restraint system, limb restraint devices, and parachute/torso harness. A predictive longitudinal study for functional anthropometry should be included in such an effort.

Development Category 6.2, 6.3 **Level of Effort** A

Code No. PA-30 **Problem Area(s)** Stress Physiology/Combined Stress; Survival/Rescue/Flotation

New Requirement Define human tolerance to the noise, overpressures and toxicities from escape system explosive activation devices.

Comments: Many escape systems use explosive activation devices for canopy fracture, harness and parachute release, etc. Tolerance levels must be defined for various stresses present to ensure continued satisfactory functioning of crewmen in the later egress/recovery/survival phases.

Development Category 6.3 **Level of Effort** B

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-31 **Problem Area(s)** Mechanical Force Environment; Survival/Rescue/Flotation

New Requirement Biodynamic forces in air-to-air rescue.

Comments: Present knowledge extends to only 150 knots; if further development of concept at higher speeds obtains, additional data at these speeds will be needed.

Development Category 6.2 **Level of Effort** B

Code No. PA-32 **Problem Area(s)** Special Senses; Clinical Medicine/Physical Fitness

New Requirement Evaluation of motion sickness prevention data to select most suitable drugs for survival kits.

Comments: The effectiveness of a large variety of drugs in preventing motion sickness has been studied. This information should be analyzed to select the most effective, practical drug for both prevention and storage. It should then be included in the various types of survival kit.

Development Category 6.4 **Level of Effort** C

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-33 **Problem Area(s)** Thermal/Climatic; Survival/Rescue/Flotation

New Requirement Minimize loss of heat through hands and feet.

Comments: There are inadequate hand and foot cold protective devices in the Fleet, especially in the water environment. The role of the extremities in overall body heat management needs to be documented.

Development Category 6.2 **Level of Effort** B

Code No. PA-34 **Problem Area(s)** Thermal/Climatic

New Requirement Determine the role of various portions of the body in cold exposure body temperature regulation.

Comments: Analysis of current data and new research are required to determine what role the various portions of the body (head, trunk, arms, legs, hands, feet) play in body temperature regulation in cold exposures. From these analyses, adequate physiological criteria and specifications for the design of passive (insulating) and active (heating) protective devices may be developed to maximize survival in cold situations.

Development Category 6.2 **Level of Effort** A

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

NEW RESEARCH NEEDS

Code No. PA-35 **Problem Area(s)** Thermal/Climatic

New Requirement Biomedical assessment of the adequacy of current survival clothing.

Comments: No adequate evaluation has been conducted of the biomedical adequacy and safety of present survival clothing. In conjunction with this new initiative (to derive physiological specifications for such clothing), current survival clothing should be evaluated to determine its adequacy in meeting such criteria.

Development Category 6.2, 6.3 **Level of Effort** A

Code No. PA-36 **Problem Area(s)** Thermal/Climatic

New Requirement Definition of the basic neurohumeral mechanism for body temperature control and evaluation of methods to enhance its effectiveness during exposure of aircrewmen to severe cold stress.

Comments: If the basic neurohumeral mechanism for body temperature can be understood, it might be stimulated (through drugs or other means) or otherwise altered to act more effectively in an extremely cold exposure situation, thereby prolonging the survival time of crewmen and enhancing rescue possibilities.

Development Category 6.1 **Level of Effort** B

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

CHAPTER 4

Life Support and Survival Systems

Mr. Dino Mancinelli, Chairman

The history of the development of life support and survival systems has been one of ongoing change. The equipment that is developed is never optimal; it must be continually updated, improved, and changed. It is always being redesigned by the user, who expresses the need for change verbally, in writing, and with considerable vigor. The user, of course, is reflecting the advent of new missions, new tactics, and new aircraft in naval aviation. Therefore, under present R&D practices, no development program can ever really terminate. The need for improvement and change is always there. However, by review of our goals and our development procedures, we may increase the effectiveness of the R&D process.

The ultimate goal in the development of life support and survival systems is the shirtsleeve environment module. The modular cockpit can provide a normal and relatively constant environment which removes the requirement for much of the personal equipment worn by pilots today. With this cockpit, designers can design internal components specifically for the protection that is required for the pilot. Thus, instead of designing an ejection seat having the dual purpose of escape and restraint, the capsule seat can be designed solely in terms of comfort, compatibility with movements of the pilot, and, to some extent, crash protection. Likewise, there would be no aviator's helmet used in a capsule environment. Instead of designing, as is the case today, a crash helmet which must provide protection against impact and buffeting as well as be a platform to carry the visor, oxygen mask, and communications system, only a head restraint system would be required. The job of the design engineer is greatly simplified and the life of the pilot is much improved. These are ultimate goals, however, which will not be realized for many years. Even then, since existing aircraft cannot be capsularized, current concepts of personal equipment would have to be maintained.

Equipment Development

The development of life support and survival systems for aviation is in a state of change. The ways of doing business that sufficed ten or fifteen years ago are no longer appropriate. The following sections describe some of the dimensions of this change. These discussions represent partially the direction in which the field seems to be going, partially the direction in which I think it should go.

Equipment Integration By Mission. The greatest need at the present time, in the field of personal equipment development, is for the integration of all such equipment into a total

assembly dedicated to a given mission. Personal equipment for a given type of aircraft will therefore be standardized to some extent. This means that the fighter pilot may look somewhat different from the attack pilot in terms of his gear. Both will present a very different appearance from that of helicopter and patrol pilots. This program should simplify our development problems and at the same time result in better acceptance and utilization of the equipment by aircrewmen.

Philosophy of Protection. A major change is taking place in the philosophy under which protective equipment is developed. In the past, protective equipment was designed for the specific emergency. This approach now is being changed so that the first priority in equipment design becomes inflight acceptance and compatibility with flight operations; secondarily, the amount of protection that can be provided without compromise of the priority requirement is determined. This change in philosophy results from years of experience with items of equipment such as the exposure suit. Here a pilot is required to wear a piece of equipment which will maintain life in frigid water for many hours. As a result, his ability to fly his airplane is seriously degraded. The new philosophy is that it is better to have 100 percent of the aircrewmen partially protected, and perform better, than it is to provide 100 percent protection for a small percentage of the aircrewmen, and degrade performance in the process.

Under the new philosophy, an NADC committee reviewed the current inventory of equipment categories, not necessarily each piece of equipment, to determine changes which would be required. It was found, first, that the personal equipment categories fell into three specific groupings. The first group consisted of the equipment items carried in aircraft with powered escape systems; the second of items carried in aircraft without powered escape systems (manual escape); and the third of equipment found to be constant across aircraft irrespective of the escape system used. With this categorization, a top priority design criterion seems to have been identified. Under this criterion, a primary consideration in the design of personal equipment is that it be either crash resistant *or* compatible with air combat maneuvering. Crash resistant items, such as would be required for the nonescape type of aircraft (helicopters and patrol aircraft), would have to be capable of sustaining high G impact and then of providing the required environmental protection. ACM-compatible items, such as would be required in fighter aircraft, would need to be very light, have a minimum profile, and not impair peripheral vision so that under high G maneuvering the equipment would not create any problem related to posture, mobility, or vision.

Equipment Performance. The ongoing NADC equipment review is also concerned with the performance characteristics of items of protective equipment. In this review, three classes of performance have been established: that afforded by existing equipment; that considered state-of-the-art performance; and that which represents ultimate or optimum performance. Use

of these performance criteria allows us to make judgments as to the development necessary to go from present performance through the intermediate step of state-of-the-art performance and on to optimum performance. This exercise is of value in deciding the relative amount of effort required in the 6.1, 6.2, and 6.3 funding categories. Where, for a given protection requirement, the difference between present and optimum performance is small, a 6.4 program would be required. Where the difference is large, there may be a requirement to return to a 6.1 program and proceed through the entire development cycle.

Funding Priorities. Too often the designers of protective equipment have been forced by Fleet requirement to produce a piece of equipment in a very short period of time. As a result, the most obvious solution or concept is selected and then pressed into the development phase to produce the item of equipment with minimum delay. Because the equipment is urgently needed, and because, in most cases, it is to some extent better than the existing equipment, the new item is put into Fleet use immediately without the proper operational evaluation and without the proper production engineering. As a result, for many years thereafter there is an ongoing process of correcting or improving that piece of equipment simply because the development job was not really accomplished in the first place.

Haste in placing protective equipment into the Fleet leads to funding deficiencies in two categories. The first is 6.1 funding (basic research) which should be used more extensively to establish multiconcept formulations and to make a scientific determination of the best concept before embarking on 6.2 and 6.3 programs. Second is a deficiency in 6.4 funding, which, if used more extensively, would allow NADC to take the advanced development prototype and perfect it before it is issued as a required piece of equipment. In short, a truly effective and balanced development cycle is going to require an increase in the relative expenditures in the 6.1 and 6.4 funding categories. In terms of money alone, the greatest need is in the 6.4 area; in terms of planning for expenditures, the greatest need is in the 6.1 area.

Current Programs

There are a number of programs underway at NADC which are aimed at the development of specific items of life support and survival equipment. However, there are three principal programs which should be described briefly as they represent the thrust of the NADC effort.

Flight Equipment Integration. The integration of all flight equipment within the major mission categories is one of the most prominent programs. In the course of the integration process, redesign is also being accomplished in order to increase inflight acceptability as opposed to emergency protection. While protection *per se* remains a very important part of the design concept, it will no longer be the master when the design process calls for trade-off to be made.

The aim of this program is to provide an integrated protective equipment package which is most compatible with the performance required of an aircrewman during a specific mission. This package should also provide adequate protection for most situations but should not be so encumbering or restrictive as to reduce the functional effectiveness of an aircrewman or his acceptance of the package.

Oxygen Generating System. A large program in the personal equipment area deals with onboard oxygen generation. This program is dedicated to the generation of oxygen in the aircraft while in flight. This is a necessary program, not because current aircraft liquid oxygen systems are inadequate, but because ground support and shipboard support problems for liquid oxygen systems are increasing.

The combat situation demands a high generation rate of liquid oxygen aboard an aircraft carrier to resupply aircraft flying a number of missions a day. For this reason, most carriers have at least two oxygen generating plants working full time. Even so, supply requirements cannot always be met and it is often necessary to have liquid oxygen in portable tanks flown aboard. There also is the problem, looking a bit to the future, of the Sea Control Ship which will house V/STOL aircraft utilized both for low altitude surveillance and high altitude, high speed flight. These aircraft obviously must be supplied with oxygen quickly. At present, there is no feasible way to manufacture liquid oxygen aboard a Sea Control Ship. Supply by tankage would present tremendous logistics problems. An oxygen generating system aboard the aircraft is the only practical solution.

The major problem is not so much the development of a generator; this has been done and proved to be feasible, but is one of retrofitting any new system into existing aircraft in terms of the limited space, weight allowance, and power available. The advantage of an inflight generating program will not be realized unless aircraft carriers no longer require liquid oxygen generating plants. For this reason, within the Navy, the program calls for the total transition from liquid oxygen to onboard oxygen generators for all carrier-based aircraft within a reasonably short time frame. At the moment, the biggest problem precluding this transition rests with aircraft power. It is necessary to keep the utilization of aircraft power at a minimum, which means either phase-scheduling the power and prestoring some greater amount of oxygen, or increasing the capability of the aircraft to provide more power. Neither is easy or particularly desirable.

The development of onboard generating systems is a joint Air Force/Navy program which is proving successful both in terms of development progress and in management techniques. Management authority in this program is shared by category. The Air Force is the lead manager for closed oxygen generating plants; the Navy is lead manager for open oxygen generating plants. The investigation of new methods and new materials for oxygen production

is jointly shared by the Air Force and the Navy. This continual staggering of management authority precludes the overloading of one service, removes the element of interservice competition, and establishes a good rapport between the two services.

Integrated Crew Module. Initial work is being done toward a design concept for an integrated crew module. We feel that the integrated crew module could solve practically all of the existing life support problems. We would have not only a cockpit specifically designed to be compatible with flight requirements, but one which could serve as a survival cockpit if required. In the event of an emergency, the pilot would stay within his capsule and survive on water with the capsule serving as an enclosed life raft, or survive on land with the capsule serving as a shelter. At the same time, he would be afforded reasonable protection in a BW/CW situation and would also have some protection against the thermal and flash effects from nuclear detonations. Internally, the cockpit geometry could be redesigned to be more advantageous for flight requirements since there would be no requirement to maintain a powered seat groove for the ejection system. Finally, an added advantage would be the use of the cockpit module itself as the escape vehicle. With this type of escape, expensive electronics and avionics components would be part of the capsule and ultimately could be recoverable. In all, the integrated crew module provides many solutions for the range of problems now facing protective equipment designers.

Problems

There are two problems related to the development of life support and survival systems which are worth noting. These are:

Life Sciences Data. There is a tremendous need in the personal equipment design field for physiological tolerances and end points. For example, there is no clear definition of the amount of impact protection required in an aviator's helmet. In the case of multiple stresses, information is even more sparse. We do not know, for instance, the combined effect of oxygen concentration, cockpit pressure, and thermal conditions on the acceleration tolerance of the aviator. Will his tolerance be improved, degraded, or remain the same? Answers to questions such as these are not available. However, this does not necessarily mean that the work itself has not been conducted. In many cases, it probably has been done. The major problem remains, as was noted in the Orlando meetings, that we lack a documented assessment of these kinds of evaluations, in which the information has been collated and specifically presented in a form that the engineer can use.

The same situation exists with respect to human factors information, and here a very thin line is drawn between human factors data and physiological data. In general, issues such as "fatigue effects" are viewed as being within the human factors field. Here we need to know,

for example, the extent to which heat and bulk contribute to fatigue in the use of an exposure garment and the point at which the fatigue causes a significant reduction in performance capability. We do not have a clear specification of the "design boundaries" within which we can operate and still not impair performance.

Coordinated Funding Programs. The members of the Technical Workshop can make a significant contribution to progress in the protective equipment field by working toward a master program plan under which funding can be coordinated. Too often, various groups are competing with each other for funds on the basis of independent program plans which do not represent a concerted effort to accomplish the entire job. The final program plan developed should be acceptable to CNO, CNM, BUMED, NAVAIR, ONR, and any other Navy office working toward our common goals. Through the efforts of the Technical Workshop, perhaps we can proceed toward this coordinated plan.

LIFE SUPPORT AND SURVIVAL SYSTEMS

Operational Need/Threat	Performance Capability			Flight Phase				Mission						Development Category/Priority			Level of Effort				New Work Unit	New Res. Code*
	Present	State-of-Art	Ultimate/Opt.	N	E	ESC	S/R	F	A	P	H	V/S	S-3	6.4	6.3/6.2	6.1	A	B	C	D		
1. HEAD PROTECTIVE SYSTEMS Head-mounted equipment degrades mission performance; is unstable under the dynamic loading of ACM and crashes, causes increased hazard during crashes, and is a contributor to aviator fatigue.	Weight 5.0 lbs.	Weight 2.25 lbs.	None required	X	X	X		X	X		X	X	X	HP—weight 2.25 lbs.				X			X(6.4)	
	Peripheral vision restriction 30%	Peripheral vision restriction 5%	None required	X				X	X		X	X	X	HP—peripheral vision			X				X(6.4)	
	Thermal comfort poor	Water-cooled	None required	X				X	X		X	X	X		HP—water-cooled		X				X(6.2)	LS-1
	Sound attenuation max. 30 db H.F.	Sound attenuation max. 40 db H.F.	Aircraft requirement	X				X	X		X	X	X		HP—sound attenuation		X					
	Mask system flammable	Mask system flameproof	Not man mounted	X	X			X	X			X	X		HP—fire-resistant materials suitable for O_2 system		X					LS-2
	Head restraint nonexistent	Inflatable collar	—		X	X		X	X		X	X	X		HP—inflatable head restraint			X				
	VTAS & other helmet-mounted display devices not integrated	Complete integration	Aircraft mounted systems	X				X	X						HP—display device integration	P—develop visual capabilities & limitations assessment methods; specify design criteria	X				X(6.1)	LS-3
	Face & eye protection unsatisfactory	Complete impact, day/night flashblindness	Aircraft mounted systems	X	X									HP—develop shatterproof high optical quality, single visor system with day/night protection	P—electro-optic flashblindness system	P—advanced flashblindness protective methods	X				X(6.1)	LS-4 LS-5
	Dynamic mike comm. system unsatisfactory due to weight/bulk/quality	Skin contact mike & miniature earphone	No head-mounted communications system required	X											HP—develop NAACH system		X				X(6.2)	LS-6

*See New Research Needs.

PRIORITY:
C = CRITICAL
HP = HIGH PRIORITY
P = PRIORITY

FLIGHT PHASE:
N = NORMAL INFLIGHT
E = INFLIGHT EMERGENCY AND CRASH
ESC = EMERGENCY EGRESS
S/R = SURVIVAL AND RESCUE

MISSION:
F = FIGHTER
A = ATTACK
†P = ASW/PATROL
H = HELICOPTER
V/S = V/STOL
††S-3 = S-3 AIRCRAFT
†P – Also includes transports.
††S-3 – Listed separately due to ejection seats.

LEVEL OF EFFORT REQUIRED:
A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

LIFE SUPPORT AND SURVIVAL SYSTEMS

Operational Need/Threat	Performance Capability			Flight Phase				Mission						Development Category/Priority			Level of Effort				New Work Unit	New Res. Code*
	Present	State-of-Art	Ultimate/Opt.	N	E	ESC	S/R	F	A	P	H	V/S	S-3	6.4	6.3/6.2	6.1	A	B	C	D		
2. EVALUATION AND ASSESSMENT OF HEAD PROTECTIVE SYSTEMS Coupling of equipment to head is unstable under ACM and crashes; optimum distribution and maximum tolerable weight of helmets has not been determined.	Rough specification	Computer math model	Dynamic head neck dummy based on math model data	X	X	X		X	X	X	X	X	X		HP—computer math model	HP—dynamic head neck dummy	X				X(6.1)	LS-7
3. TORSO MOUNTED EQUIPMENT (GEN.) Present equipment has poor integration of components, is only 50% fire-retardant. There are no provisions for universal camouflage; weight and bulk are unacceptable. Equipment has a poor military appearance.	Layered configuration	Integrated assembly	Mission-specific protective clothing & devices	X	X	X	X	X	X	X	X	X	X		HP—aircrew protective clothing and devices system (ADO 45-67)		X					
	Fire-retardancy 50%	90%	100%	X	X	X		X	X	X	X	X	X		HP—totally fire-retardant assembly		X					
	Camouflage tropic only	Arctic & tropic	Global				X	X	X		X	X		P—arctic & tropic camouflage	HP—global camouflage capability		X					
	Weight 40-50 lbs.	20-25 lbs.	15 lbs. max.	X	X	X	X	X	X	X	X	X	X	HP—weight reduction to 20-25 lbs.	HP—weight reduction to 15 lbs. max.		X					
	Appearance poor	Neat military	Neat military	X				X	X	X	X	X	X		P—appearance			X				
4. ANTI-G PROTECTION Present antiblackout systems provide inadequate protection for sustained ACM engagements. Future aircraft will require greater "G" protection.	Cement construction anti-"G" suit. 6 "G" sustained	Heat-sealed construction anti "G" suit. 8 "G" sustained. Anticipatory system	Supinating seat 10-20 G sustained. No suit required	X				X	X			X		HP—anticipatory "G" system, heat-sealed	HP—supinating seat		X X				X(6.4) X(6.2)	LS-8

*See New Research Needs.

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MISSION:
- F = FIGHTER
- A = ATTACK
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- S-3 = S-3 AIRCRAFT

LEVEL OF EFFORT REQUIRED:
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Operational Need/Threat	Performance Capability: Present	State-of-Art	Ultimate/Opt.	Flight Phase: N	E	ESC	S/R	Mission: F	A	P	H	V/S	S-3	Development Category/Priority: 6.4	6.3/6.2	6.1	Level of Effort: A	B	C	D	New Work Unit	New Res. Code*
5. FLOTATION/ANTI-EXPOSURE SYSTEM Present flotation/antiexposure systems are bulky, require ventilation, and generally degrade aircrew performance, mobility, and efficiency.	Constant wear cemented rubberized fabric	Heat-sealed preserver/modular exposure system	Open weave suit with foam-in-place flotation/exposure protection	X	X	X	X	X	X	X	X	X	X	HP–heat-sealed preserver/modular exposure system	HP–foam-in-place for flotation/anti-exposure protection	P–foam-in-place technology	X X				X(6.4)	LS-9
6. EMERGENCY EGRESS SYSTEMS Present emergency egress systems are generally adequate. However, helicopter crews have no inflight escape capability; minimal capability exists to escape from adverse attitudes, altitudes and sink rates. Physiological protection is minimal for high "Q" ejections, and no capability exists to recover aircrews from "off-the-carrier" ditching accidents. Current ejection seats do not provide the required negative "G", pelvic and crash impact restraint.	No inflight escape capability from helicopters	Ejection seats	Separable cabin/capsule			X					X			C–provide ejection/extraction seats in applicable helicopters	C–safe escape from helicopters within envelope of 100 ft/100 kts & 500 ft/zero kts. Separable cabin		X X				X(6.3) X(6.4)	
	Adverse attitude escape capability only above 500' AGL	Safe escape from 100' AGL inverted	Safe escape from 50' AGL & above			X		X	X		X	X	X		C–vertical seeking escape capability		X					
	No information provided on escape system capability with changing flight conditions	Safe ejection envelope indicator		X	X			X	X			X	X		HP–safe ejection envelope indicator		X					
	Aircrew injuries result during high "Q" ejections (airspeed $\geq$400 kts)	Advanced aircrew restraint system (safe ejection up to 600 kts)	Safe ejection up to Mach 1.5			X		X	X			X			HP–advanced aircrew restraint systems	P–foam-in-place technology for aircrew protection from high "Q" forces	X				X(6.1)	LS-10
	No capability exists for escaping aircrews to maneuver away from hostile forces	Provide maneuvering capability range 60 NM	Provide flyaway escape capsule			X		X	X			X			HP–aercab operation: 100 kts, 10,000 ft. alt., range 60 NM P–flyaway escape capsule		X				X(6.2)	LS-11

*See New Research Needs.

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Operational Need/Threat	Performance Capability: Present	State-of-Art	Ultimate/Opt.	Flight Phase: N	E	ESC	S/R	Mission: F	A	P	H	V/S	S-3	Development Category/Priority: 6.4	6.3/6.2	6.1	Level of Effort: A	B	C	D	New Work Unit	New Res. Code*
6. EMERGENCY EGRESS SYSTEMS (CONT.) Present emergency egress systems are generally adequate. However, helicopter crews have no inflight escape capability; minimal capability exists to escape from adverse attitudes, altitudes and sink rates. Physiological protection is minimal for high "Q" ejections, and no capability exists to recover aircrews from "off-the-carrier" ditching accidents. Current ejection seats do not provide the required negative "G", pelvic and crash impact restraint.	Less than optimum escape system. Excessive maintenance. High weight	Maximum performance ejection seat Minimum maintenance Low weight				X		X	X			X	X		HP–maximum performance ejection seat (MPES)		X					
	Inadequate negative "G", pelvic & crash impact restraint	Automatic powered inertia reel with negative "G" strap		X	X	X		X	X			X	X	HP–automatic, powered inertia reel with negative "G" strap			X				X(6.4)	
7. EVALUATION AND ASSESSMENT OF ESCAPE AND RESTRAINT SYSTEMS Aircrew physiological tolerance limits are not fully defined for ejection accelerations and rotational forces. No validated "human" dummy is available to aid in selecting between candidate escape, restraint and/or energy attenuation systems.	Tolerance limits not fully defined	Define aircrew tolerance limits				X		X	X			X	X		P–define total air crew tolerance limits		X				X(6.2)	LS-12
	None (rough manikin only)	Computer math model	Validated "human" dummy		X	X		X	X	X	X	X	X		HP–computer math model	HP–validated "human" dummy	X X				X(6.1)	LS-13

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Operational Need/Threat	Performance Capability: Present	State-of-Art	Ultimate/Opt.	Flight Phase: N	E	ESC	S/R	Mission: F	A	P	H	V/S	S-3	Development Category/Priority: 6.4	6.3/6.2	6.1	Level of Effort: A	B	C	D	New Work Unit	New Res. Code*
8. FIXED AIRCREW SEATING AND RESTRAINT SYSTEMS																						
Aircraft seats, restraint and energy attenuation systems do not adequately protect aircrews against crash impact forces. Armored crew seats are excessively heavy. Head restraint systems are not available for aircrews in fixed seat type aircraft.	Restraint system manual, multi-point release	Integrated harness single point release		X	X	X		X	X	X	X	X	X		HP–integrated harness with single point release		X					
	Seating (impact/loads) Aircrew 10G combined	Aircrew 40/40/10G			X					X	X	X			HP–fixed crew seats		X					
	Troop - 4G combined	Troop 20/20/10G			X					X	X	X			HP–troop seats		X					
	Pass - 4G combined	Pass 20/20/10G			X					X	X	X			HP–passenger seats		X					
	Armored seats (wt.) 250 lbs.	150 lbs.	50 lbs.	X	X	X				X	X	X		HP–150 lb. armored seat	P–50 lb. armored crew seat	P–materials develop for lightweight seat	X				X(6.4)	LS- 14
																	X		X			
	None available	Inflatable collar	"Airbag" type restraint devices		X					X	X	X			HP–inflatable collar		X					
															P–airbag restraint		X				X(6.2)	LS-15
9. PERSONNEL PARACHUTES																						
Present parachutes are not fire-resistant, impose excessive loads on the crewman during opening shock and generally require excessive maintenance.	Highly combustible	Fire-resistant	Fireproof			X		X	X	X	X	X	X		HP–fire-resistant personnel parachutes	P–fireproof personnel parachutes	X				X(6.1)	LS-16
																		X				
	No shock force attenuators	Built-in opening shock & snatch force attenuators				X		X	X	X	X	X	X		P–built-in opening							
	120 day min. maintenance cycle	5-7 year shelf life vacuum packed	Indefinite shelf life with vacuum packing	X				X	X	X	X	X	X		HP–vacuum packed 5-7 year shelf life		X					
															P–indefinite shelf life			X			X(6.2)	

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LIFE SUPPORT AND SURVIVAL SYSTEMS

Operational Need/Threat	Performance Capability			Flight Phase				Mission						Development Category/Priority			Level of Effort				New Work Unit	New Res. Code*
	Present	State-of-Art	Ultimate/Opt.	N	E	ESC	S/R	F	A	P	H	V/S	S-3	6.4	6.3/6.2	6.1	A	B	C	D		
10. AIRCRAFT INSTALLED LIFE SUPPORT SYSTEMS Present oxygen breathing supply systems impose limitations on the aircraft mission duration and on the carrier operations due to logistic support and safety problems associated with LOX production, storage, and handling. Present aircraft environmental control systems require excessive power and space aboard the aircraft, and are inefficient.	LOX system with: – 8 hr. maint. cycle – Minimum 10-minute a/c turnaround time – Excessive support requirements – Safety hazard	Onboard O_2 generator –1000 hr. maint. cycle – 0 to 5 min. a/c turn-around time – Support requirement minimized – No hazard	Onboard O_2 generator using new inorganic chemical sorbent mass –Sealed unit –No maintenance –Low power –Low weight	X	X	X		X	X	X		X	X	HP–1000 hr. oxygen generator	P–onboard O_2 generator using new inorganic chemical compound		X X				X(6.4) X(6.2)	LS-17
	LOX system with diluter-demand type breathing devices – Excessive support requirements		Onboard O_2 enriched air system –Minimum support requirements	X	X			X	X	X		X	X		P–enriched air oxygen system		X					
	High pressure gaseous emerg. oxygen system – Excessive support requirements	Solid chemical emergency oxygen system –Minimum support requirements		X	X	X		X	X	X		X	X	HP–solid chemical emergency oxygen system			X				X(6.4)	
	Heavy, bulky air conditioning systems – 35 lbs. – 400 cu. ins.		Single rotor internal energy separator BTU removal rate: 14000/hr. – 12 lbs. – 100 cu. ins.	X	X			X	X	X		X	X		HP–energy separator max. 12 lbs. 100 cu. ins.		X					

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Operational Need/Threat	Performance Capability			Flight Phase				Mission						Development Category/Priority			Level of Effort				New Work Unit	New Res. Code*
	Present	State-of-Art	Ultimate/Opt.	N	E	ESC	S/R	F	A	P	H	V/S	S-3	6.4	6.3/6.2	6.1	A	B	C	D		
11. SURVIVAL AND RESCUE SYSTEMS FOR DOWNED AIRCREWS																						
Present survival and rescue systems are generally adequate; however, numerous lives are needlessly lost due to lack of protection, inadequate protection or insufficient reliability of survival equipment in general.	Manual release of parachute to preclude shroud line entanglement	MANSAFE I —Automatic chute release, preserver and raft inflation	MANSAFE II —Extension of MANSAFE I to provide "off-the-carrier" ditching recovery of aircrews			X	X	X	X			X	X	C—MANSAFE I	C—MANSAFE II		X				X(6.4)	
	Poor performance of inflation systems under arctic conditions	Advanced inflation systems	Foam-in-place inflation systems for life-saving devices				X	X	X	X	X	X	X		HP—inflation systems development	HP—foam-in-place technology for life-saving devices	X X				X(6.1)	LS-18
	High maintenance and high incidence of damage to life rafts due to inadequate raft protection in storage	Rigid raft containers for storage of multi-place life rafts		X	X	X				X	X			P—rigid containers for storage of multi-place life rafts.			X				X(6.4)	
	No search and rescue "drop kit"	Droppable SAR kit-wing station mounted					X	X	X	X	X	X	X	P—droppable SAR kit-wing ordnance station mounted			X				X(6.4)	

*See New Research Needs.

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NEW RESEARCH NEEDS

Code No. LS-1 **Problem Area(s)** Thermal/Climatic; Stress Physiology/Combined Stress

New Requirement Development of a water-cooled liner for aircrew protective helmets.

Comments: Current protective helmets degrade aircrew performance by creating high heat loads. Development of a water-cooled helmet liner appears feasible to offset this thermal stress.

Development Category 6.2 **Level of Effort** A

Code No. LS-2 **Problem Area(s)** Accident Prevention

New Requirement Development of fire-resistant materials suitable for use in airborne oxygen mask systems.

Comments: Silicon and natural rubber materials currently used in oxygen masks will support combustion. Numerous occurrences of inflight oxygen mask fires are known to have caused accidents and fatalities. Development of a fire-resistant material for use in oxygen mask systems would eliminate this problem.

Development Category 6.2 **Level of Effort** A

Level of Effort

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NEW RESEARCH NEEDS

Code No. LS-3 **Problem Area(s)** Special Senses; Stress Physiology/Combined Stress

New Requirement Display device visual criteria.

Comments: The design criteria for the visual characteristics of display devices such as virtual image, holographic, and cathode ray tube crew-mounted displays have not been determined. Development engineers need this data in a usable form to aid in the development of helmets and helmet-mounted display systems.

Development Category 6.1 **Level of Effort** A

Code No. LS-4 **Problem Area(s)** Mechanical Force Environment; Performance and Selection

New Requirement Shatterproof, high optical quality, single visor system with day/night protection for aircrew helmets.

Comments: Current helmet visors require the use of two separate visors to gain both day and night protection. These visors have poor optical quality, scratch easily, and are not completely shatterproof. They also contribute to the excessive weight of the helmet which degrades aircrew performance.

Development Category 6.4 **Level of Effort** A

Level of Effort

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NEW RESEARCH NEEDS

Code No. LS-5 **Problem Area(s)** Special Senses; Performance and Selection

New Requirement Development of advanced concepts for flashblindness protective systems.

Comments: Present flashblindness protective systems are excessively heavy and bulky. Investigation of new concepts to provide flashblindness protection is required to eliminate weight and bulk problems and to provide the required level of protection from nuclear flashes.

Development Category 6.1 **Level of Effort** A

Code No. LS-6 **Problem Area(s)** Special Senses

New Requirement Development of nonacoustic audio coupling to the head (NAACH) system for aircrew communication.

Comments: The ambient noise in many types of aircraft, especially helicopters, makes communication difficult and sometimes impossible. Efforts to remedy this situation have led to the development of a new type of transducer which does not couple to the airborne noise field. This system operates by vibration of the skin tissue which transmits the sound to/from the user. Further refinement of this system is necessary in order to make it suitable for use with aircrew protective helmets.

Development Category 6.2 **Level of Effort** A

Level of Effort

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NEW RESEARCH NEEDS

Code No. LS-7 **Problem Area(s)** Mechanical Force Environment; Performance and Selection

New Requirement Development of an evaluation method for assessment of head protective system.

Comments: Head-mounted equipment degrades mission performance, is unstable under dynamic loading of ACM and crashes, causes increased hazard in crashes, is a major contributor to aviator fatigue. An evaluation system is needed which includes: (1) a dynamic head-neck dummy reproducing head-neck performance in three dimensions, to 4,000 G/sec, through selected range of vibration frequencies, to 200 G/peak; (2) a head-mounted equipment CG location device, 3D; and (3) means to measure CG shift occurring during dynamic ACM conditions and crashes.

Development Category 6.1 **Level of Effort** A

Code No. LS-8 **Problem Area(s)** Mechanical Force Environment

New Requirement Development of improved antiblackout systems for tactical aircraft.

Comments: Current acceleration protective systems are only effective up to about +6 G. In the near future, acceleration forces in excess of +10 G may be imposed due to advanced aircraft and the tactics employed. Development of a supinating seat appears to be the only feasible way of providing aircrews with the required level of protection in these advanced aircraft systems.

Development Category 6.2 **Level of Effort** A

Level of Effort

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NEW RESEARCH NEEDS

Code No. LS-9 **Problem Area(s)** Survival / Rescue / Flotation

New Requirement Foam-in-place flotation and antiexposure protection.

Comments: Present antiexposure suit designs are debilitating and restrict aircrew performance. Life preservers currently used are subject to damage during aircraft egress and require much maintenance. Development of an open weave antiexposure suit (like the present Nomex flight suit), which would not require ventilation or cooling, is highly desirable. With the utilization of foam-in-place technology, it is likely that such a combination antiexposure/flotation garment can be developed successfully.

Development Category 6.1, 6.2 **Level of Effort** A

Code No. LS-10 **Problem Area(s)** Survival / Rescue / Flotation; Mechanical Force Environment.

New Requirement Investigation of new concepts to provide high "Q" protection for aircrews.

Comments: High speed escape from aircraft frequently results in major and/or fatal injury to the crew. Application of the foam-in-place concept to this problem appears to have a high potential for success. Basic research and studies must be conducted in order to fully assess the potential of this concept.

Development Category 6.1 **Level of Effort** A

Level of Effort

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NEW RESEARCH NEEDS

Code No. LS-11 **Problem Area(s)** Mechanical Force Environment; Survival/Rescue/Flotation

New Requirement Flyaway escape system.

Comments: To minimize injuries during escape from high speed aircraft and to maximize the aircrewman's chance for rescue after ejection over enemy territory, a flyaway capsular escape system will be needed in new high performance aircraft.

Development Category 6.2 **Level of Effort** B

Code No. LS-12 **Problem Area(s)** Mechanical Force Environment

New Requirement Define aircrew tolerance level for ejection accelerations, ejection rotational forces and energy attenuation systems.

Comments: Aircrew physiological tolerance limits are not fully defined for ejection accelerations and rotational forces. The proper design of escape systems and energy attenuation systems is dependent upon these data which must be provided in a form usable by the design engineer.

Development Category 6.2 **Level of Effort** A

Level of Effort

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NEW RESEARCH NEEDS

Code No. LS-13 **Problem Area(s)** Mechanical Force Environment

New Requirement Development of a "validated" human dummy to aid in evaluation of escape and restraint systems.

Comments: Human subjects can be used to make evaluations. Permission to use them will probably soon cease. Subject to subject variation is considerable and tests are extremely expensive, cumbersome, and time-consuming. A dummy can be developed by using present state-of-the-art limbs and torso and developing a new head-neck section using NAMRL math model of human head-neck data for performance specifications.

Development Category 6.1, 6.2 **Level of Effort** A

Code No. LS-14 **Problem Area(s)** Mechanical Force Environment; Survival/Rescue/Flotation

New Requirement Development of new lightweight/high energy attenuation materials for fixed aircrew seats.

Comments: Aircraft seats, restraint systems, and energy attenuation systems do not adequately protect aircrews against crash impact forces. Present materials utilized in the construction of these seats are excessively heavy, especially in armored crew seats.

Development Category 6.1 **Level of Effort** A

Level of Effort

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NEW RESEARCH NEEDS

Code No. LS-15 **Problem Area(s)** Mechanical Force Environment; Survival / Rescue / Flotation

New Requirement Aircrew impact protection.

Comments: The development of the "airbag" restraint/crash impact protective system is being pursued for commercial automobiles and, to a limited extent, for aircraft. Investigation of this concept for application to the problem of crash impact protection in military aircraft appears to offer the potential for improved aircrew survivability.

Development Category 6.1 **Level of Effort** A

Code No. LS-16 **Problem Area(s)** Survival / Rescue / Flotation

New Requirement Development of fireproof materials for personnel parachutes.

Comments: Navy Safety Center data show the loss of several aircrew personnel due to destruction of the parachute canopy by fire during parachute descent. This is an ever-present hazard to aircrews during low level ejections when it is possible for the crewman to fall into the fireball of his burning aircraft.

Development Category 6.1 **Level of Effort** B

Level of Effort

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NEW RESEARCH NEEDS

Code No. LS-17 **Problem Area(s)** Maintenance

New Requirement Zero maintenance onboard oxygen generating system for military aircraft.

Comments: The maintenance and logistic requirements of current aircraft oxygen systems are excessive. They impose limitations on the aircraft mission duration and on carrier operations due to the production, storage, and handling of liquid oxygen. The development of an onboard oxygen generating system with a zero maintenance requirement is the ultimate goal. Such a system can be developed by using a new inorganic chemical sorbent mass.

Development Category 6.3 **Level of Effort** A

Code No. LS-18 **Problem Area(s)** Survival/Rescue/Flotation

New Requirement Development of foam-in-place technology for lifesaving devices.

Comments: Foam-in-place has numerous applications. In the survival situation, it can be utilized rather than rubber inflatables to serve as a life raft and as personnel flotation devices (preserver). Under arctic survival conditions, shelters could be devised from foam-in-place. However, basic research must be conducted to determine the application and optimum means for storage, release and distribution of the foam.

Development Category 6.1 **Level of Effort** A

Level of Effort

A – Work on this problem is imperative to support mission needs.
B – Work is desirable to provide a better data base to support this need.
C – Work is needed but adequate effort is being supported in other Navy, Air Force or civilian research programs.
D – No further effort is needed in this research area to meet the needs of naval aviation.

CHAPTER 5

Human Effectiveness

Commander James E. Goodson, MSC, USN, Chairman

Problem

Naval aviation systems fall short of their goals in mission effectiveness because of the poor integration of man as a functional systems component. Optimal integration will require significant advances in human factors engineering, training, and selection technologies. These in turn depend upon the definition of man's performance characteristics as a systems component, and upon the development of methodologies for utilizing this information in the most effective manner.

Man is a necessary, but awkward, component of naval aviation systems. He is necessary because of his highly sophisticated transducer properties, his capacity to store, manipulate and retrieve information, and his great variety of transfer functions expressed in response outputs obtainable from complex stimulus inputs. He is awkward because of the paucity of information available to describe his performance characteristics as a systems component. This lack of information results in the delivery of systems to the Fleet for which the operator is not qualified. The hardware presents inoperable controls, undecipherable displays, and sequences of tasks which are impossible to perform.

Goal

The goal of the Human Effectiveness program is to incorporate appropriate considerations of the human component in naval aviation systems so as to increase mission effectiveness of these systems during operational deployment.

Approach

In order to attain this goal, the Human Effectiveness R&D program must (1) define the critical performance characteristics of man as a systems component, (2) develop methodologies for assuring the implementation of this information in operational and training systems, and (3) develop appropriate criteria and techniques for assessing and enhancing man's performance capabilities in these systems.

Requirements and priorities for Human Effectiveness R&D programs are derived from "threat briefs" and documentation such as that provided for this Technical Workshop, and from direct consultation with the three major user communities, namely the operational

squadrons, the development community, and the training community. The guiding policy in program development is to provide a capability for responding to immediate user problems in a timely manner, while developing more generic information which will help to avoid the occurrence of similar problems in the future.

A major concern in the development of Human Effectiveness programs is to ensure that the programs are responsive to real problems, and that the information developed is nontrivial and will apply to future questions. R&D program areas are derived from groups of specific problems being experienced by the user communities.

Where practical, development of these programs shall: (1) address specific aircrew performance requirements identified by the user communities as limiting factors in mission effectiveness; (2) develop appropriate quantitative performance data related to these requirements; (3) recommend procedures for enhancing performance; and (4) demonstrate quantitatively the effects of enhancement procedures upon mission effectiveness. Information and methodologies thus developed shall provide the basis for recommendations to the Fleet, and to training and development communities which will lead to improved mission effectiveness of naval aviation systems. Development of Human Effectiveness programs shall provide the basis for methodologies which evaluate the effects of training procedures, simulation and human engineering implementation upon mission effectiveness. Near-term projects are developed in response to immediate user problems; mid-term programs will be responsive to more than one problem; and far-term programs will apply to a still larger family of problems within a problem area.

Problems identified by a user are rarely defined explicitly, and are almost never quantified. The initial near-term R&D response should always be a better definition of the human effectiveness aspects of the problem, and a best effort at quantifying the degree to which man's performance effectiveness impacts the mission problem.

Generally, problem identification by a user is made in the context of an anticipated approach to its solution. This is not always the most effective R&D approach to alleviating the problem. Human effectiveness problems should be approached by careful analysis of the state of relevant knowledge and of the applicability of each of the three main methods available for implementing corrective changes, namely selection standards, training requirements, and human engineering design specifications. Further, human effectiveness problems identified by different user communities are not independent. It is important that Human Effectiveness program development assures coordination and communication of requirements and developments across the user communities as well as across related laboratories.

Human Effectiveness R&D Program

The achievement of Human Effectiveness R&D goals depends upon the acquisition and implementation of information concerning basic human capabilities and limitations relevant to Fleet mission effectiveness. User problems which are in critical need of R&D response are organized and presented under the program's technical areas in the following table.

Table 1

Critical Problems of Human Effectiveness R&D Program

I. **Sensory/Display Requirements**
   - A. Vision
     1. Air-to-Air Target Acquisition
     2. Air-to-Surface Target Acquisition
     3. Visually Coupled Systems
     4. Scan of Visual Displays
     5. Advanced Displays
     6. Simulation Displays
     7. Visual Requirements for Carrier Landing
     8. Visual Countermeasures
     9. Raster Displays
   - B. Audition
     1. Noise Level
     2. Auditory Communications
   - C. Vestibular
     1. Motion Sickness Side Effects
     2. Perceptual and Control Errors
     3. Disorientation Effects
   - D. Sensory Utilization

II. **Performance Capabilities**
   - A. Operational Performance Assessment
     1. Inflight Performance
     2. Airborne Radar Intercept
     3. Landing Signal Officer
     4. Air Combat Maneuvering
   - B. Complex Performance Characteristics
     1. Human Factors Engineering Design Criteria
     2. Environmental Effects
     3. Long-term Multicrew Operations

III. **Selection**
   - A. Measurement of Cognitive and Noncognitive Factors
   - B. Semiautomatic Test Revision
   - C. Differential Prediction
   - D. Longitudinal Assessment

IV. **Training**
   - A. Training System Development and Assessment
   - B. Cost-effective Simulation
   - C. Basic Skills of Pilot Performance
   - D. Technical Training

V. **Human Engineering Requirements**
   - A. Methodology
     1. Function Allocation
     2. Test and Evaluation
   - B. Design
     1. Workload
     2. Human Factors Engineering Applications
     3. High "G" Crew Station
   - C. Integration
     1. Systems Development
     2. Voice Interactive Systems and Human Factors Engineering of Advanced Man-machine Interfaces

I. Sensory/Display Requirements

Sensory mechanisms endow man with highly sophisticated and sensitive transducer properties. He obtains all his information about his environment through these mechanisms. Most characteristics of displays, and some characteristics of controls, must be guided by the performance characteristics of these transducer mechanisms. The principal characteristics considered today by designers of hardware and by screeners of personnel who operate the hardware involve intensities, frequencies, contrasts, and separations of stimuli. These are important, and there is a great deal of data available concerning them. Some of the data are relevant to naval aviation problems, and some are misinterpreted to be relevant. It is important to determine which is which, and to fill in the gaps.

For the most part, sensory requirements now guiding selection, training, and human engineering design draw upon the state of knowledge of the 1930's, with emphasis upon the transduction of static and stable stimuli. The implied assumptions are that the eye works like a camera, and the ear like a series of tuning forks. However, man's sensory systems are attuned to dynamic as well as static stimuli. When man is presented with sustained static displays, he quickly adapts and becomes unresponsive. Unfortunately, designers often seek to eliminate the dynamic aspects of the sensory environment, and force unnatural static inputs. Systems effectiveness can be greatly enhanced by understanding and better utilizing man's dynamic sensory capabilities both in specialized selection and in designing his tasks.

Operational Goals.

A. Increase operational effectiveness of naval systems by more efficient use of the sensory capabilities of the human component. Ensure against overloading modalities with information or overloading sensory mechanisms with damaging levels of energy.

B. Utilize more effectively all of man's sensory capabilities through new knowledge and resulting new developments in display technology. Resulting increases in efficiency will reduce manpower and training requirements and increase mission effectiveness by increasing the volume and accuracy of information transduction.

C. Develop improved decision rules for matching personnel perceptual trait capabilities to job requirements.

Constraints. The necessary technology and facilities are available to accomplish most of the goals outlined. Additional personnel and funds are required to accomplish these goals in a reasonable amount of time. Advancement in certain areas will constitute "scientific breakthroughs" and perhaps challenge the state of the art in supporting technologies. However, there is a great deal to be accomplished before this becomes a limiting factor.

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Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
I. SENSORY/DISPLAY REQUIREMENTS **A. Vision** 1. Air-to-Air Target Acquisition. Tactical advantage in air-to-air combat depends upon early visual acquisition and continued visual tracking of airborne targets. Significant aircraft damage and personnel injuries are due to midair collisions under VFR conditions.	a. Initial visual acquisition occurs at ranges far inferior to calculated visibility ranges. b. Midairs and near misses occur frequently under VFR, even under Air Traffic Control warning.	a. Develop and demonstrate methods for quantifying and improving air-to-air visual acquisition performance.	a. Analyze visual functions involved. b. Relate performance on existing vision tests to ratings of air-to-air acquisition ability. c. Determine specialized training benefits. d. Survey human engineering aids.	a. Quantify air-to-air acquisition performance and relationships to vision tests, training and human engineering aids. b. Document requirements for means of improving acquisition performance. c. Demonstrate quantitatively impact of recommendations upon air-to-air acquisition. d. Compare direct visual acquisition with capabilities using sensor/display.	a. Investigate the following critical visual functions involved in the acquisition process: 1) Peripheral acuity 2) Visual fields 3) Visual control of eye movements 4) Accommodation 5) Contrast 6) Visual tracking and scan processes 7) Determinants of fixation 8) Saccadic suppression 9) Dynamic visual acuity b. Relate laboratory measures of these functions to acquisition performance. c. Develop mass testing procedures for critically related functions. d. Measure capabilities of aviation personnel on critical functions. Develop norms, selection criteria, and project realistic estimate of visual acquisition capabilities.

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Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
A. Vision (Continued) 2. Air-to-Surface Target Acquisition. Important portions of the naval aviation mission depend upon direct visual reference to surface targets, e.g., combat air support, low-level navigation, and rescue. Air Force, with coordination and support from Army and Navy, has led in portions of air-to-ground acquisition R & D. Emphasis is upon modeling and simulation rather than visual functions involved. Tri-service working group is headed by Navy member.	a. No predictive indices of capability are presently available. b. There is inadequate classification of terrain, background, and impact of terrain on visual acquisition.	a. Systematize context variables in air-to-ground acquisition. b. Quantify individual acquisitive capabilities. c. Analyze trade-off of direct visual versus sensor/display effectiveness. d. Evaluate possible means of improving air-to-ground acquisition.	a. Participate in tri-service evaluation of air-to-ground acquisition models and aids. b. Provide research results from above evaluation program, where applicable. c. Participate in evaluation and working group efforts.	a. Quantify air-to-surface acquisition performance and relationships to vision tests, training and human engineering aids. b. Document requirements for means of improving acquisition performance. c. Demonstrate quantitatively impact of recommendations upon air-to-surface acquisition. d. Compare direct visual acquisition with capabilities using sensor/display.	a. See Vision, Problem 1.
3. Visually Coupled Systems. There is need to reduce the physical task required for certain control functions (e.g., weapons aiming) by delegation of such functions to servo control by eye position.	a. Some capability exists for servo control by helmet position, but none for eye position. Head-mounted VCS systems are being developed with independent and unrelated display design criteria.	a. Assess capabilities for accurate visual fixation control and driving servo control by use of eye position. Determine VCS design criteria, requirements and limitations in terms of pilot mission and visual system capabilities.	a. Are contingent upon progress in other areas of visual research.	a. Determine display and system dynamics criteria as related to visual system functioning.	a. See Vision, Problem 1 with emphasis upon: 1) Visual control of eye movements 2) Visual tracking 3) Determinants of visual fixation.

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Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
A. Vision (Continued)					
4. Scan of Visual Displays. Visual task loading of many aviation systems is excessive. Display design should provide optimum cues for efficient visual scan.	a. Display design has emphasized resolution requirements, but acquisition (scan) efficiency has not been explored systematically.	a. Define visual display characteristics which impact scan efficiency, and define optimal display design characteristics for scan. Reduce "inside" visual task loading.	a. Evaluate alternative display designs for efficient and accurate visual scanning.	a. Analyze display scan requirements for visually taxed crew positions. b. Define display design characteristics which impact efficient acquisition (scan) as opposed to resolution.	a. See Vision, Problem 1.
5. Advanced Displays. Advanced display technology is being proposed for aviation systems without adequate information about the consequent visual requirements. Information is required concerning relative advantages and disadvantages of advanced display concepts.	a. Capabilities for considerable evaluation are within state-of-the-art. No systematic evaluation of visual characteristics is ongoing.	a. Develop criteria for design characteristics and utilization capabilities of advanced visual displays. Provide capability for early evaluation of advanced display design concepts.	a. Determine impact upon performance effectiveness of: 1) Head up displays 2) Helmet mounted displays 3) Holographic displays 4) LED displays 5) Plasma displays 6) Predictor displays b. Develop capability for general testing of visual characteristics of advanced display concepts.	a. Evaluate design assumptions concerning visual characteristics, including: 1) Monocular versus binocular 2) Vergence/accommodation conflict 3) Virtual image.	a. See Vision, Problem 1 with emphasis upon: 1) Stimulus determinants of accommodation 2) New display capabilities (e.g., color, specific contrast gradients and element density) upon visual performance.

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
A. Vision (Continued)					
6. Simulation Displays. Current and anticipated ground-based aviation training requirements place great emphasis upon the simulation of visual reference outside the cockpit.	a. Considerable advanced display technology is available and under development. Visual requirements and visual performance criteria have not been defined.	a. Define outside display requirements for full mission simulation.	a. Analyze display requirements for outside reference. b. Evaluate current display alternatives for presenting outside visual reference.	a. Identify deficiencies in technology, and recommend directions for development. b. Determine impact of false visual cues, sensory conflicts and interactions, and visual distortions upon performance. c. Determine trade-off of methods of image generation (CGI, 3-D model, film).	a. Identify and define requirements for: perspective stereopsis, motion, color, contrast, and angular extent of display. 1) Perspective stereopsis 2) Motion 3) Color 4) Contrast 5) Visual field size
7. Visual Requirements for Carrier Landing. Accidents/incidents during carrier landings occur more frequently during night than day operations. Major task differences are visual.	a. Current night carrier landing efficiency is poorer than for day.	a. Reduce accident/incident rate for night carrier landings to that of daylight recovery operations.	a. Analyze visual and nonvisual aspects of carrier landing operations. b. Determine landing performance differences due to visual factors. c. Identify critical visual reference requirements.	a. Document visual reference requirements for night carrier landing, and demonstrate impact upon landing performance.	a. Identify and investigate visual functions critical to night operations for specialized selection criteria.
8. Visual Countermeasures. Dependence of naval aviation missions upon visual functions implies vulnerability to visual countermeasures.	a. Classified.	a. Develop visual countermeasures, and reduce vulnerability to visual countermeasures.	a. Assess current capabilities and defenses. b. Evaluate effectiveness of supposed countermeasures.	a. Identify any applications or areas of visual countermeasures which may be peculiar to Navy missions.	a. Investigate extraneous stimulus properties which will degrade performance in visual resolution, acquisition, and tracking.

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Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
A. Vision (Continued)					
9. Raster Displays. Emphasis on improved airborne attack effectiveness will require specification of display design requirements for raster displays (e.g., TV and IR).	a. Data are system specific and reflect unsystematic reference to system characteristics (scan, lines, brightness, contrast, format) and some corresponding operator performance capability.	a. Undertake systematic multivariate quantification of operator target acquisition performance with raster displays.	a. Identify possible display image characteristics relevant to target acquisition and their interaction with current measures of image quality (e.g., MTF, SNRD, etc.).	a. Develop performance trade-off curves relating target characteristics, image characteristics, and image quality measures.	a. Develop a prioritized and updatable hierarchical matrix relating to display characteristics, target characteristics, operator performance, and display quality for prediction of raster display requirements and criteria.
B. Audition					
1. Noise Level. Almost without exception, the noise levels produced by Navy aircraft exceed hazardous noise exposure criteria. Such high noise levels degrade communication (see 2 below), hearing capacity, as well as ongoing job performance. The "auditory fatigue" experienced after long exposure to relatively high noise levels can result not only in short-term performance (i.e., communication) impairment but also accelerated long-term hearing loss with resultant economic, manpower, and safety problems.	a. Present protective devices, when properly worn, result in approximately 25 dB attenuation to aircraft noise. It is known that such attenuation is insufficient for precluding accelerated hearing loss. b. In addition, existing hearing protective devices are not appropriate for all work task situations.	a. Determine the extent of hearing loss and performance decrement incurred by existing noise levels in naval aircraft. Specify and define those environments in which protective devices are lacking or inappropriate. Effectively reduce aircraft noise level experienced by flight personnel.	a. Develop, test, and evaluate protective hearing devices and determine operational environments for which they are appropriate. b. Further our present understanding of the auditory process and variables which enhance, prolong, and degrade this sensory capability.	a. Reevaluate protective hearing devices in the appropriate operational setting and make modifications as possible and/or feasible. b. Obtain data on critical design characteristics of hearing protective devices (e.g., effectiveness, comfort, durability). Determine empirical and Fleet validation of such critical design characteristics. c. Develop training aids and guides for proper use of hearing protective devices among flight personnel. d. Reexamine existing human factors specifications and standards in terms of noise exposure limits.	a. Continue updating effectiveness of protective devices. b. Apply criteria of critical design characteristics which have been validated and continue updating such criteria. c. Continue to monitor noise levels of new naval aircraft to determine compliance with safety standards.

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
B. Audition (Continued)					
2. Auditory Communication. Optimum transmission, reception, and processing of auditory information is frequently jeopardized by one or more of the following factors: (a) noise masking of the auditory signal, (b) impaired hearing due to auditory fatigue (see 1 above), (c) poorly maintained or inadequate equipment and hearing protective devices (see 1 above), (d) utilization of nonoptimal signals and/or procedures, and (e) the poor ability of some individuals to transmit and receive signals in noise.	a. In general, noise levels experienced in the majority of Navy aircraft are not overly hazardous in the long term to the hearing of personnel who wear properly fitted flight helmets or noise attenuating headsets. The noise levels in many aircraft are sufficiently intense to reduce the efficiency of voice communications and other auditory signal detection. Moreover, existing hearing-protective devices are not appropriate for all work situations.	a. Determine the extent to which aircraft noise levels have a potentially serious effect upon communication. Examine the feasibility of improving existing communication (and protection) systems as well as developing alternative auditory communication/signal systems.	a. Specify those aviation systems and settings in which the ambient noise level poses serious hazards to communication. b. Investigate possible improvements (apparatus and procedures) in existing communication systems. c. Determine the feasibility of developing alternative auditory communication/warning systems such as through the use of combined sensory systems (hearing-vision, hearing-tactile, etc.) in the presentation of "messages" or the use of the two ears as separate information processing systems of sequentially presented material. d. Evaluate current auditory selection standards and determine the feasibility of a "secondary" selection system for individuals whose work involves the transmission, reception, and processing of auditory information.	a. Continue to monitor the noise environment of new and evolving naval aircraft in terms of hazard levels and communication quality. b. Develop standardized test procedures and materials for evaluating (1) the capability of radio communication systems in new Navy aircraft to transmit and receive intelligible speech; and (2) the ability of aircrew personnel to hear speech in their accoustical environment. c. Continue research into the application of new auditory communication/warning systems to improve existing material and to reduce current visual overloads upon aircrew personnel. d. Maintain other research and monitoring efforts as systems and conditions warrant. e. Amend existing human factors specifications and standards as new information (engineering, physiological, psychological) is uncovered.	a. Extend the knowledge of man's auditory system and his ability to transmit and receive auditory signals in stressful situations. b. Continue research into the human auditory system and the monitoring of auditory standards in developing aircraft systems-hardware as necessary.

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Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
C. Vestibular					
1. Motion Sickness Side Effects. Prolonged exposure to the moving aircraft environment (ASW and SAR missions) results in greater and larger degrees of performance degradation due to motion sickness side effects, especially the nausea and sopite syndromes. In addition to the physical motion, interactive variables such as the type of visual displays present have been found to influence the incidence and degree of motion sickness and its side effects.	a. Quantifiable force profiles for ASW and SAR aircraft. b. Anti-nausea drugs not entirely effective. c. Partial prevention by means of personnel selection and programmed adaptation procedures possible but generally impractical. d. Excellent facilities (apparatus and procedures) for investigating the mechanisms, both environmental and physiological, underlying the elicitation of motion sickness and its debilitating side effects.	a. Determine incidence of nausea and sopite syndromes under operational conditions. Reduce frequency of motion sickness and its side effects which contribute to human-error accidents.	a. Measure force profiles in ASW and SAR aircraft under operational conditions. b. Simulate acceleration profiles in the laboratory. c. Evaluate new anti-nausea drugs and new methods of administering "old" anti-nausea drugs under operational conditions. d. Determine extent and effect of sopite and nausea syndromes in operational settings. e. Measure intra- and inter-individual differences in susceptibility to the nausea and sopite syndromes. Establish feasibility of increased selection program. f. Investigate mechanisms underlying elicitation of nausea and sopite syndromes. g. Determine rate of acquisition and decay of adaptation effects under simulated and laboratory conditions. Validate under operational conditions. Establish feasibility of adaptation training program.	a. Develop special medications and instructions to reduce the selection problems to a minimum. b. Conduct surveys of new types of ASW and SAR aircraft (flight profile and incidence of the nausea and sopite syndromes). c. Continue studies of mechanisms underlying elicitation of the nausea and sopite syndromes. d. Continue clinical investigations if necessary. e. Extend investigations, using human and sub-human subjects. f. Develop modifications for visual displays to reduce motion sickness and its side effects.	a. Develop sufficient understanding of motion sickness and its side effects to minimize its occurrence in future systems. b. Establish human engineering design principles for visual displays to minimize motion sickness effects from this source. c. Identify central nervous system mechanisms interposed between vestibular stimulation and responses.

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Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
C. Vestibular (Continued) 1. Motion Sickness Side Effects (Continued)			h. Evaluate the effects of current aircraft displays on motion sickness. i. Begin investigations of central nervous system changes in animal subjects exposed to moving environment and compare with effects of other stressors.		
2. Perceptual and Control Errors. The dynamic change in force and torque profiles to which man is exposed by maneuvers of new aircraft (such as F14 and V/STOL) introduce the potential of an increased frequency and magnitude of perceptual and control errors.	a. Limited understanding of the basic flight conditions conducive to the elicitation of the oculogravic and oculogyral illusions, their dynamic interaction, and attendant visual performance degradation. b. Partial laboratory simulation of acceleration generated by vectored dynamic thrust in aircraft. c. Specially designed and fabricated devices for visual perception of both earth-vertical and earth-horizontal and for recording these variables and the body position of the subject. d. Miniaturized triaxial acceleration recorder for obtaining force profiles.	a. Establish the magnitude of perceptual errors and factors influencing the probability of control errors introduced by F14 and V/STOL aircraft. Develop specialized selection, training, and human engineering requirements leading to the improvement of operator effectiveness.	a. Obtain force profiles of F14 and V/STOL aircraft. b. Simulate relevant F14/V/STOL profiles and validate laboratory findings in the operational aircraft. c. Devise instruction manuals and demonstration methods to train personnel about the perceptual errors and factors which influence the translation of perceptual into control errors. d. Validate existing tests and new generation tests against performance criteria in advanced aviation programs such as F14 and V/STOL programs.	a. Continue laboratory and operational studies as necessary. b. Evaluate special instruments designed to counteract perceptual errors. Elucidate especially compelling perceptual errors which may require special automatic control features. c. Update instruction manual and procedures for personnel training. d. Conduct appropriate studies dealing with new types of V/STOL aircraft. e. Determine need for changes or additions to aircraft display panels.	a. Continue studies as necessary.

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Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
C. Vestibular (Continued)					
2. (Continued)	e. Known predictive value of a subject's reactions to interacting orientation and stimuli as they affect his success in naval aviation training.				
3. Disorientation Effects. Air-to-ground visual target acquisition is critical to mission effectiveness for the Attack Aircraft (VA) community. The following represent specific problem areas which significantly degrade performance in air-to-ground target acquisition and which require resolution to improve mission effectiveness. a. Motion sickness which is induced by optical devices with stabilization and zoom magnification features. The devices were designed to enhance air-to-ground acquisition. b. Pilot disorientation is induced when scenic displays, which are provided by sensor systems, display scenes that are at variance with the direct view along the aircraft axis.	a. Assessment of optical devices/displays has resulted in the documentation of motion sickness/disorientation side effects. However, no systematic effort has been initiated for the purposes of identifying the determinants of these conditions or for generating testable recommendations in terms of selection/training or task redesign for the improvement of operator effectiveness.	a. Increase the probability of target detection by developing and demonstrating methods for quantifying and improving the performance degradation effects of motion sickness and operator disorientation in respect to the specified situation.	a. Evaluate visual enhancement. b. Estimate causes of side effects (motion sickness, disorientation). c. Develop prototype procedure for evaluating overall effectiveness of devices. d. Determine magnitude of combat orientation error (OE) hazard from display depicted frame of reference.	a. Quantify air-to-ground visual acquisition performance and develop relationships to specialized selection and/or training methods to minimize motion sickness and optimize visual detection. b. Determine selection and training countermeasures for OE hazard. c. Determine feasibility of instrument countermeasures by using periphery of display.	a. Investigate the critical functions involved in understanding the man/device interface necessary for optimizing vision enhancement by optical aids on motion platform. b. Investigate and specify visual-postural determinant of orientation error to provide human engineering guidelines for future design of such devices.
c. Laser designator systems contain optical distortions which degrade tracking performance and cause motion sickness in some operators.	a. Naval laboratories have or will have the necessary personnel and facilities for obtaining the required data.	a. Produce a laser designator system that is less detrimental to operator performance.	a. Determine the magnitude of optical distortion tolerable. b. Explore alternative means of display presentations.	a. Determine basic principles underlying adaptation to distortion. b. Develop techniques for increasing levels of adaptation.	

HUMAN EFFECTIVENESS

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
C. Vestibular (Continued) 3. (Continued) c. (Continued)			c. Select operators more resistant to visually induced motion sickness.	c. Develop systems trade-off data through advanced simulation techniques.	
D. Sensory Utilization Increases in visual information requirements have resulted in the use of other sensory input channels without regard to channel capacity, information requirements, sensory conflicts, relevant stimuli, etc.	a. Some continual research and development is being pursued for each sensory input made without regard for their relationship to information requirements, task complexity or system design.	a. Develop and define those human factors engineering information processing and control performance criteria required to operate advanced systems.	a. Evaluate multi-channel versus single-channel inputs in complex performance tasks. Determine the relevant interactions and priorities of different methods of information presentation.	a. Develop design and utilization criteria for the most effective means of information presentation in complex systems.	a. Develop performance/task complexity/sensory modality/temporal trade-off criteria for appropriate allocation of information to sensory channel. These should be incorporated into a design and utilization guide.

II. Performance Capabilities

Human performance is a critical element in aviation safety and combat effectiveness. However, due to the limitations rendered by the nature of the operating environment, system complexity restraints, and economic considerations, human performance criteria in aviation weapons and training systems are critically deficient.

The objective of this area of investigation is the specification and measurement of aircrew performance in operational and training systems for the purposes of assessing and improving human performance capability in operational environments. The data thus developed will provide human performance criterion measures for the specification of performance capabilities and for the assessment and improvement of training effectiveness, operational readiness, and human factors engineering requirements in naval aviation systems. Recommendations for the improvement of human capabilities through specialized screening, training, and/or human engineering augmentation will be based upon analyses of these performance data, and will be evaluated by quantitative methods.

There is a great amount of human performance data available in the psychological literature. However, most of the laboratory studies from which these data are derived bear little relationship to the real world problems of performance measurement in naval systems. This disparity is largely due to the difficulties involved in recreating operational environments in the laboratory and to the lack of valid performance criteria in the operational context. Major breakthroughs are required before these problems can be solved. Meanwhile, measures of performance obtained under conditions simulating the operational environment contribute significantly to the formulation of design criteria.

Man's complex performance capabilities are influenced significantly by environmental stimuli, and by the complexity of the information processing requirements, and the quantity and intricacy of required physical manipulations. They are further influenced by uniquely human traits such as inference behavior and perceived stress and by various forms of misperception such as illusion or disorientation which result from unusual or discordant sensory information. Since man's behavior is not independent of environment, it is necessary to study complex perceptual processes in relation to various relevant environmental variables like noise, hyper- and hypobaria, magnetic fields, and temperature extremes.

Principles have been derived for minimizing confusion in displayed information, and determinations made on how to best allocate information processing functions between man and machine. The most desirable match is not necessarily one which oversimplifies an operator task. Better performance is frequently attained by permitting the human operator to perform

certain integrations that could be assigned to the machine. In addition, the results can suggest countermeasures and training programs for special problems occurring in military settings which represent unusual or unnatural environments for man.

Previous studies of work/rest cycles are adequate to use as general guidelines. There has been a tendency, however, to neglect consideration of cycles other than the circadian. Some studies have been made of the effects of long duration aircraft flights on performance efficiency. Other studies have considered the relationship between prolonged wakefulness and performance on selected skilled tasks. Not all of these data are in agreement. However, sufficient data exist to suggest relationships between blood hormone levels, time of day, duration of nonsleep period, and performance. These data should be confirmed, and the experimental protocols expanded to consider the impact of either more rapid or slower cyclic changes on performance. The interaction of these factors with current suggested work/rest schedules could be significant.

Operational Goals. The goal of the R&D effort in this area is the quantification of human performance in a way that is meaningful to the user communities. One of the major tasks is the determination of the most useful measure of human performance for development decisions. Performance may be expressed in terms of probabilities, such as the probability of an operator detecting a radar target. Performance may be expressed in terms of the duration of the response, such as the amount of time that the operator can effectively track a target. Performance may be expressed in terms of the strength of the response, or in terms of the accuracy of the response. Performance measures must be concerned with the variety of differences among individuals or groups of individuals assigned to operate weapons systems. R&D efforts in this area should provide capabilities for the following:

A. Evaluate utilization of operator skills and function allocation in attempting to develop the most efficient interaction between man and machine.

B. Identify environmental factors which are detrimental to man's performance and determine conditions under which acceptable performance may be maintained.

C. Identify skills and characteristics peculiar to individuals which make them more or less suitable for mission requirements.

D. Utilize appropriate work/rest cycles so as to improve performance through the reduction of fatigue states.

Constraints. The major constraints in this area are produced by the lack of appropriate criteria and methodologies for the evaluation of the role of man's performance in the mission effectiveness of a system. These limitations are reflected in the general lack of predictive validity, face validity, and reliability, and in an insufficient taxonomy of performance functions.

Very little capability currently exists for objectively assessing and predicting the quality of individual performance in operational aviation missions. There are strong indications that aviation personnel vary significantly in their ability to perform required operational functions. Some critical examples of where such individual differences can impact system performance are: air combat missions, long-range air-to-air intercept, air-ground attack, visual target acquisition and identification, and carrier landing ability. The present subjective rating systems do not allow the clear identification and analysis of critical performance variables which are necessary for the assessment and enhancement of the human contribution to the mission effectiveness of operational systems.

Real progress in this area depends, to a considerable extent, upon some technological breakthroughs in the area of precise measurement of complex performance. The current development of computer-based measurement systems for performance measurement promises to greatly accelerate progress in this area.

Present facilities must be augmented if the full spectrum of objectives in this area is to be achieved. In particular, facilities must be expanded in order to bring the full range of relevant perceptual skill and environmental variables into controlled laboratory evaluations.

The number of trained personnel in this area must be increased. Current manning levels will support the initial exploratory efforts, but the larger scale follow-on efforts will generate substantially higher personnel requirements.

HUMAN EFFECTIVENESS

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
II. PERFORMANCE CAPABILITIES **A. Operational Performance Assessment** 1. Inflight Performance Assessment. Realistic assessment and projection of operational effectiveness of systems requires knowledge of human performance capabilities. The objective evaluation of inflight performance in the operational and training communities is deficient. This deficiency includes the lack of methodologies for deriving and stating criteria in measurable terms and techniques for objectively measuring inflight performance against these criteria. These methodologies and techniques are required in order to evaluate operational readiness, and training and human factors engineering effectiveness.	a. Very little capability exists for objectively assessing and predicting the quality of individual performance in operational aviation missions. Operator performance requirements are poorly defined, and assessment techniques are subjective and casual, at best.	a. Develop and standardize inflight performance criteria. b. Develop inflight performance measurement methodology for objectively measuring performance in training and operational systems.	a. Identify Fleet training criteria critical to effective aircrew performance. b. Assess current performance measurement capability in terms of providing reliable performance data that could be used for evaluating and improving Fleet effectiveness. c. Identify alternative criteria/performance measurement strategies responsive to Fleet and training requirements. d. Order the strategies in terms of feasibility and potential payoff with primary interest in objective performance measurement.	a. Develop and validate a performance measurement methodology responsive to established Fleet training performance requirements. b. Determine requirements for actual operational measurement versus assessment in a simulated task environment.	a. Complete and evaluate assessment methodologies and apply to general criterion development problems. b. Develop performance data relevant to solutions to operational problems. c. Institute a systematic, iterative program for improving the assessment methodologies. d. Provide a means whereby definitive recommendations can be made based upon performance data for improving human capabilities through specialized selection, improved training, and/or Human Engineering to other Fleet/training problems.

HUMAN EFFECTIVENESS

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
A. Operational Performance Assessment (Continued) 2. Airborne Radar Intercept. The Radar Intercept Officer (RIO) and Air Control Officer (ACO) are required to guide one moving vehicle to intercept a moving target without actually seeing the target. In performing an intercept, the RIO and ACO utilize artificial two-dimensional displays to solve a four-dimensional spatial-relative motion problem. Added to this task are the requirements that the information be conveyed rapidly and accurately and that all tasks be performed under unusual environmental conditions. The intercept problem occurs frequently in Fleet operations and is critical to the success of missions. However, the skill with which intercepts are performed varies widely among RIOs and ACOs. The Fleet capability for performing airborne radar intercepts has not been quantified. There appears to be great variability among RIOs and ACOs in their ability to perform this critical mission function.	a. Very little capability exists for objectively assessing and predicting the quality of individual performance in operational aviation missions. Operator performance requirements are poorly defined, and assessment techniques are subjective and casual, at best.	a. Assess and improve the efficiency with which RIOs and ACOs perform intercepts in Fleet operations.	a. Assess human performance requirements and their impact upon mission effectiveness. b. Develop quantitative measures of operator performance variables related to critical mission functions. c. By means of laboratory investigations, develop procedures for the enhancement of human contribution to mission functions through function specific selection, training and/or human engineering augmentation.	a. Demonstrate quantitatively the effectiveness of enhancement procedures on the selected mission functions. b. Provide performance data, enhancement procedures, and recommendations for implementation to the operational, training and development communities for appropriate utilization in the accomplishment of their respective missions.	

HUMAN EFFECTIVENESS

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
A. Operational Performance Assessment (Continued) 3. Landing Signal Officer. Aircraft recovery represents the greatest accident risk in Fleet aviation. The Landing Signal Officer (LSO) plays an extremely important role in recovery operations. His job is highly complex and requires him to integrate several flight parameters in order to make a "wave-off/no wave-off" decision. The LSO contribution to the recovery operation is not quantified, and his performance appears to be highly variable.	a. Very little capability exists for objectively assessing and predicting the quality of individual performance in operational aviation missions. Operator performance requirements are poorly defined, and assessment techniques are subjective and casual, at best. Several sources of variability in carrier landing operations have been investigated, e.g., lighting configuration, a/c type, carrier class, and pilot experience. The LSO has been identified as an important source of variation, but his contribution has not been quantified.	a. Assess effect of LSO performance on systems variability during recovery. b. Identify the perceptual and psychomotor tasks involved, and increase safe boarding rate.	a. Assess human performance requirements and their impact upon mission effectiveness. b. Develop quantitative measures of operator performance variables related to critical mission functions. c. By means of laboratory investigations, develop procedures for the enhancement of human contribution to mission functions through function-specific selection, training and/or human engineering augmentation.	a. Demonstrate quantitatively the effectiveness of enhancement procedures on the selected mission functions. b. Provide performance data, enhancement procedures, and recommendations for implementation to the operational, training and development communities for appropriate utilization in the accomplishment of their respective missions.	

HUMAN EFFECTIVENESS

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
A. Operational Performance Assessment (Continued)					
4. Air Combat Maneuvering. The sophistication and high performance capabilities of current fighter weapons systems place a great burden upon the operator of such systems. He must gain tactical advantage over an opponent through highly stressful and complex maneuvers, anticipate and recognize his entry into an acceptable weapons launch envelop, and select, arm and launch his weapons while under a task load which would challenge his abilities even under the much less stressful conditions of simulation.	a. Very little capability exists for objectively assessing and predicting the quality of individual performance in operational aviation missions. Operator performance requirements are poorly defined, and assessment techniques are subjective and casual, at best. An Air Combat Maneuvering Range (ACMR) is scheduled to become operational in FY 74. The purpose of the ACMR is to provide a facility for safely training Navy pilots in air-to-air combat through the provision of air space and instrumentation systems which are capable of real-time monitoring and display of pertinent airplane performance parameters and weapons firing functions for one to four aircraft.	a. Develop performance criteria and performance assessment capabilities. b. Define training objectives. c. Improve Ground Instructor Pilots (GIP) use of information displayed at GIP station. d. Specify training procedures.	a. Initiate a comprehensive human factors evaluation of the Ground Instructor Pilot's (GIP) station to: 1. evaluate design against specification/standards 2. define system capabilities 3. analyze display management alternatives and trade-offs. b. Assess performance measurement opportunities based on an assessment of system capabilities. c. Initiate an effort to define initial training objectives and establish performance criteria which reflect the attainment of these objectives. d. Assist in the development of improved training procedures. e. Assess the current state-of-the-art methodology for analysis of these variables, based on system outputs of inflight aircraft performance variables.	a. Develop and validate performance measurement methodology responsive to refined training objectives. b. Evaluate the impact of developed performance measurement methodology for improving the effectiveness of the training system. c. Determine the requirements for actual operational measurement versus assessment in a simulated task environment.	a. Develop a systematic program for improving methodology of performance assessment and apply such methods, as appropriate, for assessing and improving human capabilities within the ACMR system context.

HUMAN EFFECTIVENESS

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
A. Operational Performance Assessment (Continued) 4. Air Combat Maneuvering (continued)			f. Investigate the feasibility of transitioning the program to include broader scope aircrew performance.		
B. Complex Performance 1. Human Factors Engineering Design Criteria. Crew station and panel design decisions have been dictated by factors other than operator/system effectiveness and are often manufacturer-specific. The majority of decisions on utilization of panel space have been determined by engineering preferences rather than operator requirements. Dedicated controls and displays have resulted in overcrowding of available panel space. Specifications and standards for displays, controls, and panels have not been based on established operator requirements. Frequently the specifications and standards represent an earlier state of engineering development.	a. Naval laboratories have personnel and facilities for doing this type of work. Computer graphics techniques offer a potential means for evaluating design procedures for multipurpose displays, consolidated instrument panels, and integrated controls and displays. Navy and contractor personnel are capable of evaluating the quality of the present human factors engineering standards and specifications.	a. Base all human engineering specifications and standards upon sound human performance data and system operability requirements. Panel and crew station design decisions should be based upon known operator effectiveness data with established ideal/practical trade-off costs.	a. Review existing human engineering specifications and standards for conflicting and ambiguous statements. b. Identify for modification or elimination all specifications and standards that do not have adequate supporting human performance data. c. Develop criteria for utilizing multipurpose displays and controls.	a. Develop criteria and methodology for determining and applying appropriate design weights for frequency, criticality, and available panel space. b. Develop advance computer graphics programs for simulating and evaluating panel design techniques.	a. Develop criteria for determining optimum usage of human operator information input/output functions. b. Update design specifications and standards to meet the needs of new technological developments. c. Develop integrated crew station modules.

HUMAN EFFECTIVENESS

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
B. Complex Performance (Continued)					
2. Environmental Effects. The nature of the operational mission and the specific characteristics of particular aircraft/weapons systems contribute to the effectiveness of the operator's performance. Detailed knowledge of the environmental effects upon the ability of airborne operators to perform systems functions under anticipated operational conditions is essential.	a. Little information exists concerning the impact of multiple environmental variables upon performance capabilities.	a. Determine the boundaries of the expected human performance envelope as a function of the magnitude and types of environmental demands created by any anticipated mission.	a. Validate human operator simulation concepts and programs in complex situations. b. Create human performance measurement programs which will allow data collection on complex operator tasks under anticipated environmental conditions. c. Collect and analyze human performance data under simulated "real world" conditions.	a. Develop human performance equations for related sets of tasks which predict the expected quality of operator performance as a function of environmental parameters, task complexity, and individual skill levels.	a. Develop high human operator simulation programs which can generate valid mathematical models of human performance under complex and exotic environmental conditions. Such models would allow the simultaneous consideration of systems, operator, and environmental parameters to specify system design tradeoffs and utilization strategies.
3. Long-term Multicrew Operations. The ASW mission requires not only the sustained performance of each crewmember, but the coordination of aircrew performance with that of surface and subsurface tactical platforms for mission effectiveness.	a. No standard performance measures exist for evaluating the human contribution to ASW tactical mission effectiveness. b. A few measures of aircrew (sensor operator) performance have been developed, but few, if any, measures, other than general ratings, exist to assess total crew effectiveness.	a. Develop measures of individual crewmember performance, total crew performance and system performance reflecting the coordination of tactical platforms. These are required to evaluate selection, training scheduling, work cycle duration, human engineering and crew assignment procedures.	a. Identify critical problems of the ASW mission. b. Determine the feasibility of objectively measuring these problems. c. Assess the probable impact of performance assessment relative to the defined criteria problems.	a. Develop and validate performance criteria measures. b. Apply the performance criteria and measures for purposes of improving training/selection and/or task design.	a. Define critical operator characteristics required for long-term multicrew ASW missions. b. Develop capability for improved operator selection and crew composition. c. Develop techniques for maintenance and enhancement of complex task performance involved in detection, identification and classification of targets.

III. Selection

Demands on the operators of current and evolving weapons systems are much greater than those imposed by earlier systems. Required cognitive abilities (spatial, mechanical, information processing skills) and noncognitive characteristics (personality factors and background history) may be different both in degree and in type from those assessed by present testing procedures.

Current test batteries assess cognitive and noncognitive abilities and aptitudes principally through tests in paper-and-pencil format. These tests yield content or accuracy scores with limited assessment of processing speed capabilities. Current batteries are measuring aviation related factors identified as relevant to performance in earlier weapons systems. While these batteries have been and are instrumental in reducing training attrition and in improving selection efforts, they are not in themselves sufficiently responsive to identified requirements for assessing capabilities demanded by the increasing variety of Fleet aviation jobs. Improved methods of measuring information processing abilities, including processing speed (response latencies), must be developed, and mechanisms underlying these basic abilities defined.

Personality measures have had only limited success as selection instruments when scored only for content purposes. Procedures for assessing key personality factors which reflect such noncontent information as response latency should be developed and evaluated.

In aptitude and noncognitive areas, current approaches use a single testing instrument to assess all levels of ability, with resultant loss of precision. Substantive technology is available to tailor the selection of test items to the individual via branching structures and to weight content responses through confidency testing procedures. These technologies should be adapted and evaluated for the aviation aptitude testing situation.

The greater complexity and technological sophistication of aviation systems have increased the specialization required of systems operators. Job-relevant skills and abilities differ in kind and degree across specific task situations. Selection standards and training pipeline and Fleet assignments must incorporate these varying task requirements.

The recent entry into naval aviation of a larger population of identifiable "minority groups," particularly women and blacks, creates unique selection and training considerations.

These two problems are part of the requirement to define relevant skill, ability and background differences within the entrant population and to relate these to specific task performances at the training, RAG, and Fleet levels. The mechanism for meeting this requirement is the concept of differential prediction, the meshing of varying job requirements

with the differences in individual characteristics to produce optimal manpower usage by means of accurate forecasts of differential success.

Operational Goals.

A. Develop and maintain a mass testing and prediction capability which will optimally select applicants for naval aviation training programs.

B. Improve mechanism for updating paper-and-pencil tests.

C. Develop new modes of testing.

D. Evaluate and implement tests of operator characteristics which are found by other technical areas to be critical to performance.

Constraints. The major constraint for this R&D area is caused by the lack of meaningful operational performance criteria needed to validate the selection and training process. Selection procedures are currently validated against training criteria whose relationship to Fleet performance is unknown.

Other constraints are produced by hardware and software requirements for timely retrieval and processing in the recruiting and training environments.

HUMAN EFFECTIVENESS

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
III. SELECTION **A. Measurement of Cognitive and Noncognitive Factors** 1. The current test battery (paper-and-pencil) primarily measures content and accuracy scores, with limited assessment of processing speed capability. The battery does not assess the variety of capabilities demanded by highly complex functions in the Fleet. Improved methods of assessing information processing abilities, including processing speed (response latencies), must be developed.	a. Hardware is available to address these questions. Portions of needed software are in existence. Existing technologies can be adapted. Specific research must be addressed to development and evaluation questions on the methodologies underlying these new assessment procedures, and their utility in the aviation situation.	a. Increase adequacy of cognitive and noncognitive assessment. b. Refine definitions of information processing factors and develop tests to assess newly identified abilities.	a. Determine relationships between speed of response and content performance on existing paper-and-pencil batteries. b. Develop tentative latency scoring procedures which maximize relevance of scores to job performance measures. c. Initiate identification of aviation-related abilities and characteristics not assessed by conventional batteries. d. Develop appropriate methods for response scoring speed to assess information processing skills. e. Develop personality factor measurement techniques which involve both content scoring and response latency scoring.	a. Develop testing and scoring procedures for newly identified abilities and characteristics. b. Evaluate and validate tests against training and RAG/Fleet performance to enhance primary and secondary selection and pipeline assignment. c. Improve responsiveness and precision of content scoring through item branching methodologies and confidence testing techniques.	a. Determine impact of training on identified abilities and recommend instructional techniques for skill development. b. Relate abilities and training capabilities to task requirements to assess adequacy of equipment design standards.

HUMAN EFFECTIVENESS

Problem	Current Capabilities	Research Needs: Goals	Near-Term	Mid-Term	Far-Term
B. Semiautomatic Test Revision					
1. Aviation selection tests lose their validity and reliability over time as a function of changes in cultural, recruiting, and training conditions. Desired reliability and validity of such tests can be maintained only by the timely implementation of new revisions.	a. The time required for major test revisions (approximately ten years) is not responsive. Methods for assessing validity and reliability are available. Item retrieval and selection methods will be developed.	a. Produce a system for rapid revision of the aviation selection test battery that will assure optimal validity, reliability, economy, and ease of implementation.	a. Specify all the system components and establish test item bank with provisions for updating inputs. b. Develop and/or assemble all software for battery revision on a batch processing basis.	a. Test out system with batch processing capability and develop link-up software toward final automation.	a. Develop a completely automated system that will monitor existing tests, make decisions as to need for revisions, generate the revisions, and produce a battery ready for implementation.
C. Differential Prediction					
1. Assignment to and prediction of success in training pipeline and Fleet specialties is nonoptimal, resulting in increased attrition and training costs and decreased Fleet efficiency.	a. Forecasts of success do not reflect the possibility of differing task requirements. Current understanding of Fleet skill requirements is inadequate for timely response to identifiable areas of unsatisfactory Fleet performance.	a. Develop as managerial tools, for all potential assignments, forecasts of success which incorporate differences in skills and abilities required by each assignment. b. Provide user with differential prediction information in a manner which will minimize interpretive difficulty.	a. Develop differential success prediction methods using currently available data keyed to empirical training criteria. b. Examine alternative differential prediction displays for user interpretability and acceptance.	a. Extend success criteria to RAG and Fleet levels. b. Identify skill and ability requirements of specific jobs and tasks and develop methods of measurement. c. Determine optimum differential prediction displays and implement assignment systems.	a. Develop taxonomies of skills and abilities and taxonomic relationships to job/task families. b. Define mechanisms underlying job capabilities to identify those improvable by training and to determine appropriate methods of training.

HUMAN EFFECTIVENESS

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
D. Longitudinal Assessment 1. Efforts to measure aircrew capabilities have not addressed the potential changes in basic skills and abilities which may occur as a result of the aging process or from continuing experience on the job. These changes and their impact on performance must be considered in aircrew assignments. Cross-sectional studies cannot assess directly age and experience factors. Longitudinal followups of defined cohorts over an extended time period are required to clarify intra-individual changes in capabilities.	a. Little systematic information on the effects of aging and experience on basic skills and abilities is available. Methods are adequate for measurement of many relevant factors but studies specifically cast in a longitudinal framework are needed.	a. Identify performance-relevant changes in key aircrew skills and abilities as a result of the aging process. Identify changes occurring as a result of continued job experience independent of aging. Incorporate age and experience information into job assignment decision procedures.	a. Determine preliminary performance relevant measures to be examined for change. b. Establish cohort group to be followed and take initial measures.	a. Track cohort job performance and administer followup measures. b. Initiate examination of time effects on measured variables. Determine systematic changes and tentative separation of age and experience factors.	a. Conclude followup assessments and job performance tracking. b. Isolate age versus experience effects and define processes involved. c. Determine impact of expected capability change on job assignment procedures and aircrew standards.

HUMAN EFFECTIVENESS

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
B. Cost-effective Simulation (Continued)					
2. The overriding requirement is to design and evaluate simulators in accordance with operational training requirements. This necessitates the development and validation of criteria/performance measures reflective of community needs.		a. See Cost-effective Simulation Goals	a. Develop overall study to determine the range of practical problems for the variety of training/ operational communities. Analyze training and operational communities to determine existing requirements.	a. Identify appropriate variables for training. b. Develop specific criterion measures of pilot performance. c. Develop inflight performance criteria.	a. Develop an objective and adequate evaluation system for scoring and assessing pilot performance.
3. The increase of the overall efficiency of ground-based simulators requires the development of measurement systems based on an understanding of processes in areas such as transfer of training, retention, skill acquisition, time-sharing.		a. See Cost-effective Simulation Goals	a. Compare transfer effects from part-task trainers to those from more complex simulators and determine the relative contribution of each for training defined skills. b. Develop retention measures to assess simulator training effectiveness.	a. Determine if the rate of skill acquisition and level of transfer vary in some predictable manner due to the combination of tasks and the sequence in which they are learned. b. Develop and evaluate time-sharing as a measure of skill acquisition in the simulator and validate in flight.	a. Develop scoring system for simulators which will include: 1. Problems which deal with hardware/ device capabilities, cost factors, user acceptance 2. Determination of representative events for observation 3. Specification of how best to instrument the measurement system
4. The effectiveness of ground-based simulators as a viable training method requires the development of a systematic research effort to determine where and how the simulator should be used in training. Its cost-effective value as a training device must be demonstrated quantitatively for the tasks trained.		a. See Cost-effective Simulation Goals	a. Determine how effectively flight simulators are being used at the present time. b. Determine the flight training objectives currently taught in the air which could be taught in the simulator.	a. Ascertain optimum simulator-aircraft sequencing for the acquisition of various flying skills. b. Determine the amount of simulator training necessary per skill developed to achieve a specified inflight criterion level. c. Determine where training efficiency can be improved because of increased control in the simulator environment.	a. Develop inflight data recording and automated training techniques.

HUMAN EFFECTIVENESS

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
C. Basic Skills of Pilot Performance					
1. There is a need to understand the basic skills required of a student naval aviator in order to predict future pilot performance. These basic skills should set a foundation for the highly refined skills required of a Fleet aviator who successfully flies operational types of aircraft. It follows that the testing of student pilots with regard to these basic skills would enable future pilot prediction.	a. Capabilities for accommodation to these needs are well within the state-of-the-art and NAMRL capabilities, except for possible additional manpower needs and the incorporation of a GAT-1 system.	a. Develop a taxonomy of the basic skills required of student pilots. Develop a test battery using these basic skills to predict pilot performance.	a. Develop a task analysis questionnaire of the maneuver performed by student pilots to isolate the recurring critical parts of each of the maneuvers. b. Translate these critical items into perceptual-psychomotor behavioral components.	a. Classify behavioral components into basic skills. b. Design test batteries incorporating basic skills. c. Validate these test batteries both in the air (checklist), in the laboratory (GAT-1), and in the Fleet (followup studies). d. Incorporate these test batteries as an integral part of the Prediction System.	
D. Technical Training					
1. Current maintenance procedures are being placed under an increasing strain by rapid changes in both equipment and missions, by increases in the complexity of equipment, and by the potential drop in overall aptitude of maintenance personnel.	a. Excessive amounts of time, money and spare parts are being used in both the formal schooling and on-the-job training of technicians. The technician is not viewed as "fully productive" until this training is finished, and often what he has learned does not correspond to the needs of the job he is to perform. Current aviation maintenance training employs training devices which are fabricated from the airborne equipment; this results in high cost and reduced availability of spare parts.	a. Develop a maintenance training system which simulates the hardware and the test equipment, and is interactive with a computer-aided instructional system.	a. Develop methods to analyze equipment and task commonalities, areas of maintenance training, and appropriate instructional aids which can guide and direct a comprehensive maintenance training system.	a. Demonstrate capabilities for simple and complex tasks. b. Develop cost design/utilization/performance decision tree.	a. Develop design guides which relate performance criteria, system cost, utilization, complexity, and instruction air requirements. b. Provide systematic guidance to the design of a maintenance training system.

V. Human Engineering Requirements

Military systems fall short of their goals in mission effectiveness because of poor integration of the human component. This poor integration is, in turn, due to the lack of appropriate performance criteria for the human component, and the lack of methodologies and mechanisms for implementing these criteria as design requirements during the development of systems.

Human factors engineering may be described as comprising three levels of activities: (1) the development of information on human capabilities and limitations relevant to systems effectiveness, and the development of methodologies for assessing these in operational systems; (2) the translation of this information into systems design criteria and specifications; and (3) the implementation of these human factors engineering design specifications during systems design, development, test, and evaluation. The definition and assessment of human operator characteristics as a systems component is the principal subject of the Human Effectiveness R&D program described in foregoing sections. The implementation of design specifications is an integral part of systems development, and is sponsored as a systems support function. The development of methods and techniques for the management of human factors engineering data, analyses and design requirements, and the development of new approaches to man-machine integration are clearly responsibilities of the Human Effectiveness R&D program.

Operational Goals.

A. Increase mission effectiveness of new systems by developing methods for imposing human factors engineering requirements during the earliest phases of systems development, and assuring that these requirements remain effective throughout production, test, and evaluation of the system.

B. Develop and provide new information and techniques to be used in the definition and specification of optimal control, control systems, and display systems for use by those who operate and maintain military systems.

C. Develop and provide principles for the design and layout of workspaces in military systems. This area integrates findings from the controls and display area with findings from human engineering, physical anthropology, and industrial design.

D. Develop and provide better methods for the identification of critical human engineering problems in systems development, and for the assurance of the efficient and timely introduction of human factors information in systems from the time of conception through development, test, and operational deployment.

E. Develop methods and techniques for identifying human factors problems which are critical for naval systems development, and for collecting data in a context and form which will apply to the solution of these problems.

F. Develop doctrine by which human factors engineering constraints, and the assumptions upon which those constraints were predicted, may be tested during systems development and acquisition.

G. Provide analytical methods for use during systems design and development which will contribute to effective function and task allocation, control and display placement, and man-machine trade-offs. These methods should include standard procedural requirements for human engineering analysis during design; standardized human engineering conventions; general mockup and simulation techniques; and, where necessary, mathematical and computerized man-machine models.

Constraints. Significant advances in this area are constrained only by funds, time, and competent personnel. Other major advances will require substantial breakthroughs in understanding.

The development and implementation of adequate human factors test and evaluation methods will constitute a major breakthrough. The development of human factors engineering performance specifications will depend upon progress in other areas of this program.

Operational performance criteria and the methodology for valid measurement of operational performance constitute the most critically needed developments in human factors engineering and possibly in systems development. This will constitute a major breakthrough, but should be considered high priority on a long-term commitment. The criterion for success will be the provision of operational performance curves to demonstrate the necessity of particular human factors design requirements or to demonstrate criteria for training of operators.

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
V. HUMAN ENGINEERING REQUIREMENTS **A. Methodology** 1. Function Allocation. The systematic allocation of alternative identical functions/tasks/activities to man and machine cannot be accomplished by traditional human factors engineering techniques applied during the time and economic constraints currently associated with complex weapons systems research and development	a. Only fragmented, judgmental, noniterative techniques are used in an attempt to perform a prior function allocation of man-machine functions.	a. Develop and demonstrate interrelated computer aids to assist the human factors engineer in determining optimal allocation of functions between man and machine in a Navy system.	a. Develop independent submodels for processing the various requirements of function allocation: 1. basic function allocation 2. computer-aided design 3. workload assessment 4. human operation simulation 5. crew station geometry	a. Optimize interaction by means of appropriate trade-off routines and data management systems.	a. Generate specific data requirements appropriate to function allocation. b. Become a part of the training system development process in order to maximally utilize available data, rationale, and engineering assumptions.
2. Test and Evaluation. Reasonable cost-effectiveness evaluations and design trade-off considerations are dependent upon ability to estimate total system performance capabilities which include the impact of man-machine interactions. Inadequate human factors information during these trade-off evaluations leads to a dangerous overestimation of Fleet operational capabilities.	a. The implementation of human factors considerations during systems development is largely dependent upon discrete translations of standards, specifications, and conventions into engineering design configurations, with no provision for assessing their validity or sufficiency in any particular application.	a. Develop a systematic, effective, and practical capability for the prosecution of human factors test and evaluation during the evolution of naval systems.	a. Develop a T&E methodology adaptable to system requirements.	a. Establish and develop a system for the meaningful translation of T&E findings into R&D operational system and/or training system requirements.	a. Develop a total methodological package which will allow for appropriate HFE data to be collected during partial performance testing under a variety of circumstances (field, lab, contractor for system, subsystem, or component). The package should be capable of being integrated to provide overall assessment and improvement of the system.

HUMAN EFFECTIVENESS

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
B. Design					
1. Workload. Aircrewmen are normally required during critical mission phases to perform tasks which exceed their capabilities. These overloaded conditions often result in mission failure or accidents.	a. Workload is currently defined as: $\frac{\text{Time Available}}{\text{Time Required}}$ without adequate criteria for estimation, much less for predicting overload.	a. Develop methods of measuring workload and predicting performance degradation as a function of such.	a. Define workload explicitly in terms of variables and their potential modifiers. b. Develop performance measures for these variables which are valid under anticipated operational conditions.	a. Develop prediction model and validate in terms of: 1. individual characteristics 2. time (years) 3. unusual environments 4. sense modality.	a. Develop means of performance maintenance or enhancement during times of potential overload.
2. Human Factors Engineering Application. The complex set of systems demand parameters generated by many of the more advanced aircraft and aircraft weapon systems have rendered some of the standard research designs and quantitative methods inadequate.	a. A number of multifactor research designs and a host of univariate and multivariate analysis techniques are available for adaptation to the human factors problem areas.	a. Improve the cost-effectiveness of research by more effective matching of research methodologies to the character and complexity of the problems being addressed in human factors engineering.	a. Develop a set of experimental design and analysis models that will have general applicability to human factors engineering methodological requirements.	a. Refine and popularize the human factors engineering design and analysis models for use in evaluating RFPs, plans, and contracts.	a. Continue to extend the range, sensitivity, and applicability of research and analysis models for human factors engineering requirements.
3. High "G" Crew Station. Some proposed high performance/high acceleration aircraft will expose the aircrew to G loading of over eight Gs.	a. Basic facilities are available which can be modified to meet the specific demands of this type of problem.	a. Produce the functional requirements and configuration for a high G crew station.	a. Determine the requirements for scaling arrangements. b. Develop display and control requirements for primary flight instruments.	a. Develop simulation programs to generate systems design specification and trade-off data for the high G crew station.	a. Assess the quality of operator performance under laboratory conditions which replicate the anticipated G force exposure conditions.

HUMAN EFFECTIVENESS

Problem	Current Capabilities	Research Needs: Goals	Research Needs: Near-Term	Research Needs: Mid-Term	Research Needs: Far-Term
C. Integration					
1. Systems Development. Large systems create the need to track and evaluate the effects of individual subsystem changes on the total system. The capabilities of computer management techniques are needed to supply the HFE analyst with all the implications of a given function allocation arrangement, a continuous update of all previous decisions, and assumptions as data become available.	a. It is within the state-of-the-art for computers to generate and evaluate large numbers of potential function allocations; produce geometric evaluations of man-crew station compatibilities; present graphic presentations of internal and external visual fields; and generate OSDs and FFBDs. Computers are capable of tracking HFE decisions and design assumptions in terms of later impact.	a. Need immediate feedback on impact of HFE decisions (commensurate with level of detail available) on dollar cost, weight, maintainability, reliability, training requirements, skill requirements, probability of mission success.	a. Develop computer models paralleling the system development cycle to provide assistance to HFE analyst in the areas of function allocation, procedure generation, workload assessment, crew station design, and trade-off analysis. b. Develop a data management system capable of linking the above models into a total system and capable of storage and management of all data required by this system.	a. Develop a dynamic system of computer model, computer aids, and a data management system capable of continuous iteration and update as system detail increases with each stage of the system development cycle. b. Establish an in-house HFE computer facility with dedicated computer and a ready interface for users.	a. Develop a capability for remote terminal interface with central computer facility enabling entire HFE user community access to this integrated computer system.

HUMAN EFFECTIVENESS

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
C. Integration (Continued) 2. Voice Interactive System and Human Factors Engineering of Advanced Man-Machine Interfaces. The advent of airborne computers and exotic sensing equipment has created a large number of new options for interfacing man and machines. In the past, the operator received information by sight or hearing and responded with his hands or feet. New developments make it possible to receive information through other sensory channels such as the skin and to control devices through eye movements or voice commands. Computers can receive, evaluate, display and act upon a wide variety of information sources. The efficiency of advanced aircraft and weapons systems will depend on the quality of these new man-machine interfaces. a. Effective use of voice as method for human operator to inform machines of information needed on decisions he has made and synthesized voice to receive information. b. Efficient use of where man is looking for equipment control, target designation, etc.	a. There is wide use of voice interactive systems to replace 20-30 percent of visual displays and controls. b. Remote tracking of eye position is possible with a high degree of accuracy. c. Design of systems to deliver disparate views to left and right eyes can be accomplished. d. Remote handling devices with feedback are used in research and industrial application.	a. Develop alternative methods of man-machine interfaces other than dedicated visual displays and manual controls.	a. Develop voice interactive system language requirements. b. Demonstrate prototype voice interactive systems under normal flight conditions in airborne weapons systems other than fighter and attack. c. Develop prototype demonstration of remote eye tracking in airborne applications. d. Improve design of lightweight helmet for VTAS applications. e. Develop prototype demonstration of use of stereo systems for low attitude flight control. f. Determine optimum design alternatives for five-dimensional flight controllers for advance fighter/attack/helicopter applications. g. Become familiar with software language on tactical tapes.	a. Determine methods to enhance voice recognition under high G or high vibration for adaptation of voice interactive systems in fighter and attack aircraft. b. Use computer generated symbology and pictural information to stereo scopic systems. c. Evaluate operational program analysis of tactical tapes for optimum man-computer interaction.	a. Develop man/computer voice interactive systems allowing use of complex statements by operator to inform system of requests for information, decisions he has made, and changes in equipment studies. b. Develop nonburdensome accurate eye tracking for target designation. c. Develop nonburdensome stereoscopic displays with expanded interocular base to enhance depth perception, target recognition, etc. d. Develop systems for flight control which allow operator to indicate with an integrated movement his desired flight path. The input from such device would be adapted by onboard computer to control flight surfaces.

HUMAN EFFECTIVENESS

Problem	Current Capabilities	Research Needs			
		Goals	Near-Term	Mid-Term	Far-Term
C. Integration (Continued) 3. (Continued) c. Effective use of man's unique capability to process three-dimensional visual information by use of disparate views to left and right eyes simultaneously. d. Ability to use effectively integrated multidimensional flight controls which would allow operators to utilize coordinated whole-body responses. e. Efficient software interfaces to aid in information exchange and decisionmaking in advanced airborne weapon systems.					

CHAPTER 6

Summary of New Research Needs

This chapter summarizes the new research need statements prepared by the Aviation Operational Medicine, Physiological Assessment, and Life Support and Survival Systems subcommittees in terms of recommended priority and funding level. New research need statements prepared by the Human Effectiveness subcommittee, which used a somewhat different format, can be found in Chapter 5.

To assist in future financial planning, new research needs were assigned probable funding levels of:

6.1 – Research

6.2 – Exploratory Development

6.3 – Advanced Development

6.4 – Engineering Development

A measure of relative importance among the research needs was reflected in the assignment of one of the following priority codes:

A. Work on this problem is imperative to support mission needs.

B. Work is desirable to provide a better data base to support this need.

C. Work is needed but adequate effort is being supported in other Navy, Air Force, or civilian research programs.

D. No further effort is needed in this research area to meet the needs of naval aviation.

SUMMARY OF NEW RESEARCH NEEDS

Funding Level 6.1 **Priority** A **Subcommittee** Aviation Operational Medicine

Code No.	Title	Problem Area
AOM-1	Study of Naval POW Aircrew Personnel	Performance and Selection
AOM-2	Study of Naval Helicopter Aircrews	Special Senses; Performance and Selection
AOM-5	Aircrew Personnel Physical Fitness Standards	Clinical Medicine/Physical Fitness

Funding Level 6.1 **Priority** B **Subcommittee** Aviation Operational Medicine

Code No.	Title	Problem Area
AOM-3	Aircrew Physical Qualifications Data Bank	Clinical Medicine/Physical Fitness
AOM-4	Study of FLIR-Optically Induced Motion Sickness	Special Senses; Performance and Selection
AOM-6	Biomedical Performance Predictors	Performance and Selection; Stress Physiology/ Combined Stress; Clinical Medicine/Physical Fitness
AOM-7	Audiovisual Medical Communications for LAMPS	Clinical Medicine/Physical Fitness
AOM-9	Early Noninvasive Detection of Acute Disease	Clinical Medicine/Physical Fitness
AOM-8	Followup of Human Research Subjects	Clinical Medicine/Physical Fitness

SUMMARY OF NEW RESEARCH NEEDS

Funding Level 6.1 **Priority** A **Subcommittee** Physiological Assessment

Code No.	Title	Problem Area
PA-1	Better Methods to Increase "G" Tolerance	Mechanical Force Environment
PA-6	Display Device Visual Criteria	Special Senses
PA-23	Determination of Safe Envelope for Escape Systems	Mechanical Force Environment

Funding Level 6.1 **Priority** B **Subcommittee** Physiological Assessment

PA-11	Mechanisms and Definition of Neurophysiological Fatigue	Accident Prevention
PA-13	Disorientation in Helicopter Operational Environment	Special Senses
PA-18	Sensory Modalities for Emergency Warning Indices	Special Senses
PA-19	Monitoring of the State of Pilot Alertness	Special Senses
PA-24	Human Tolerance Levels for Rotating/Vertical-Seeking Escape Systems	Mechanical Force Environment; Survival/Rescue/ Flotation
PA-36	Define Basic Neurohumeral Mechanisms for Body Temperature Control and Evaluate Methods to Enhance Its Effectiveness	Thermal/Climatic

Funding Level 6.2 **Priority** A **Subcommittee** Physiological Assessment

PA-1	Better Methods to Increase "G" Tolerance	Mechanical Force Environment
PA-3	Assessment of Negative and Lateral "G" Forces	Mechanical Force Environment
PA-10	Biomedical Assessment of Hazards from BW/CW and Lasers	Radiation/Toxicology
PA-16	Development of Improved Anthropomorphic Dummies	Mechanical Force Environment
PA-20	Functional Anthropometry	Performance and Selection
PA-23	Determination of Safe Envelope for Escape Systems	Mechanical Force Environment
PA-25	Biodynamic Envelope for Human Exposure to Parachute Opening	Mechanical Force Environment; Survival/Rescue/ Flotation
PA-28	Establish Acceptable Criteria for Parachute Oscillation and Steerability	Mechanical Force Environment; Survival/Rescue/ Flotation

SUMMARY OF NEW RESEARCH NEEDS

Funding Level 6.2 **Priority** A **Subcommittee** Physiological Assessment

Code No.	Title	Problem Area
PA-29	Determine Sizing Table for Escape Systems Based on Operational Functional Anthropometry	Performance and Selection
PA-34	Determine Role of Various Portions of the Body in Cold Exposure Body Temperature Regulation	Thermal/Climatic
PA-35	Biomedical Assessment of the Adequacy of Current Survival Clothing	Thermal/Climatic

Funding Level 6.2 **Priority** B **Subcommittee** Physiological Assessment

Code No.	Title	Problem Area
PA-4	Determine C.G. Changes of the Human Head When Wearing Protective Helmets	Mechanical Force Environment; Stress Physiology/Combined Stress
PA-5	Determine Susceptibility to Disorientation for Selection and Training	Special Senses
PA-8	Physiological/Biochemical Predictors to Determine Stress Reaction	Performance and Selection
PA-9	Long-term Effects of Combined Stress in Aviation	Stress Physiology/Combined Stress
PA-12	Vibrations in the Helicopter Operational Environment	Mechanical Force Environment; Stress Physiology/Combined Stress
PA-14	Determination of Acceptable Temperature Ranges	Thermal/Climatic; Stress Physiology/Combined Stress
PA-15	Low Grade Hypoxia and Toxicants in Aviation	Altitude; Clinical Medicine/Physical Fitness
PA-17	Delethalization of Crew Stations	Mechanical Force Environment
PA-21	Assessment of Combustion Toxicants from Materials Used in Aircraft Cabins	Radiation/Toxicology
PA-27	Quantitative Comparisons Between Test Dummy and Human Subjects for Chute Opening Shock and Landing Forces	Mechanical Force Environment; Accident Prevention; Survival/Rescue/Flotation
PA-31	Biodynamic Forces in Air to Air Rescue	Mechanical Force Environment; Survival/Rescue/Flotation
PA-33	Minimize Loss of Heat Through Hands and Feet	Thermal/Climatic; Survival/Rescue/Flotation

SUMMARY OF NEW RESEARCH NEEDS

Funding Level 6.3 **Priority** A **Subcommittee** Physiological Assessment

Code No.	Title	Problem Area
PA-2	Design Specifications for High "G" Body Positioning System	Mechanical Force Environment
PA-7	Functional Anthropometry of Naval Aircrewmen	Performance and Selection
PA-26	Develop a Better Test Dummy for RDT&E	Mechanical Force Environment; Accident Prevention; Survival/Rescue/Flotation
PA-28	Establish Acceptable Criteria for Parachute Oscillations and Steerability	Mechanical Force Environment; Survival/Rescue/Flotation
PA-29	Determine Sizing Table for Escape Systems, Based on Operational Functional Anthropometry	Performance and Selection
PA-35	Biomedical Assessment of the Adequacy of Current Survival Clothing	Thermal/Climatic

Funding Level 6.3 **Priority** B **Subcommittee** Physiological Assessment

PA-22	Toxicology of New Fire Suppressants Used in Aircraft Cabin Environments	Radiation/Toxicology
PA-30	Define Tolerances to the Noise, Pressures and Toxicities Associated with Escape System Explosives	Radiation/Toxicology; Survival/Rescue/Flotation

Funding Level 6.4 **Priority** C **Subcommittee** Physiological Assessment

PA-32	Select Most Suitable Drugs for Survival Kit	Special Senses; Clinical Medicine/Physical Fitness

SUMMARY OF NEW RESEARCH NEEDS

Funding Level 6.1 **Priority** A **Subcommittee** Life Support and Survival Systems

Code No.	Title	Problem Area
LS-3	Display Device Visual Criteria	Special Senses; Stress Physiology/Combined Stress
LS-5	Flashblindness Protective Systems	Special Senses; Performance and Selection
LS-7	Assessment of Head Protective System	Mechanical Force Environment; Performance and Selection
LS-9	Flotation and Antiexposure Protection	Survival/Rescue/Flotation
LS-10	High "Q" Protection for Aircrews	Survival/Rescue/Flotation; Mechanical Force Environment
LS-13	Escape System Evaluation Dummy	Mechanical Force Environment
LS-14	Development of Improved Fixed Aircrew Seats	Mechanical Force Environment; Survival/Rescue/Flotation
LS-15	Aircrew Impact Protection	Mechanical Force Environment; Survival/Rescue/Flotation
LS-18	Foam-in-Place Lifesaving Devices	Survival/Rescue/Flotation

Funding Level 6.1 **Priority** B **Subcommittee** Life Support and Survival Systems

Code No.	Title	Problem Area
LS-16	Fireproof Materials for Personnel Parachutes	Survival/Rescue/Flotation

SUMMARY OF NEW RESEARCH NEEDS

Funding Level 6.2 **Priority** A **Subcommittee** Life Support and Survival Systems

Code No.	Title	Problem Area
LS-1	Water-cooled Protective Helmets	Thermal/Climatic; Stress Physiology/Combined Stress
LS-2	Fire-resistant Oxygen Mask Materials	Accident Prevention
LS-6	Head System Nonacoustic Audio Coupling	Special Senses
LS-8	Tactical Aircraft Antiblackout Systems	Mechanical Force Environment
LS-9	Flotation and Antiexposure Protection	Survival/Rescue/Flotation
LS-12	Tolerance Levels for Ejection Forces	Mechanical Force Environment
LS-13	Escape System Evaluation Dummy	Mechanical Force Environment

Funding Level 6.2 **Priority** B **Subcommittee** Life Support and Survival Systems

LS-11	Flyaway Escape System	Mechanical Force Environment; Survival/Rescue/Flotation

Funding Level 6.3 **Priority** A **Subcommittee** Life Support and Survival Systems

LS-17	Zero Maintenance Oxygen Generating System	N.A.

Funding Level 6.4 **Priority** A **Subcommittee** Life Support and Survival Systems

LS-4	Improved Aircrew Helmet System	Mechanical Force Environment; Performance and Selection

APPENDIX A
PROGRAM

NAVAL AVIATION BIOMEDICINE AND HUMAN EFFECTIVENESS TECHNICAL WORKSHOP

Mills Hyatt House
Charleston, South Carolina

6–10 August 1973

Office of Naval Research
Contract No. N00014-73-C-0052

Bureau of Medicine and Surgery
Department of the Navy
Washington, D.C.

Naval Aviation
Biomedicine and Human Effectiveness
Technical Workshop
Charleston, S.C.

Monday 6 August 1973

0830 (Robt. E. Lee Rm)	Registration
0930 (Plantation Rm)	Welcoming Address/Review of Washington Meeting Captain Roger G. Ireland, MC, USN, Workshop Chairman
1000 (Robt. E. Lee Rm)	Coffee Break
1020 (Plantation Rm)	Review of Subcommittee Procedures and Administrative Matters Captain Robert E. Kinneman, MC, USN
1100 (Indigo Rm)	Initial Subcommittee Meetings A – Life Support and Survival Systems Mr. Dino Mancinelli, Chairman
(Indigo Rm)	B – Physiological Assessment Captain Laurence H. Blackburn, MC, USN Chairman
(Rice Planters Rm)	C – Human Effectiveness CDR James E. Goodson, MSC, USN, Chairman
(Cotton Exch. Rm)	D – Clinical Aerospace Medicine Captain Robert E. Mitchell, MC, USN, Chairman
1200 (Rutledge Rm)	Lunch Meeting Attendees and Guests
1330–1700	Subcommittee Meetings
1600 (Robt. E. Lee Rm)	Steering Committee and Subcommittee Chairman Meeting (10 min)

Tuesday 7 August 1973

0900–1200 (Plantation Rm)	Subcommittee Meetings
1100 (Robt. E. Lee Rm)	Steering Committee and Subcommittee Chairman Meeting (10 min)
1200	Lunch

1300–1700 (Plantation Rm)	Subcommittee A Presentation Mr. Dino Mancinelli, Chairman

Wednesday 8 August 1973

0900–1200 (Plantation Rm)	Subcommittee B Presentation Captain Laurence H. Blackburn, MC, USN, Chairman
1200	Lunch
1330–1700	Unscheduled (Rest, informal meetings, tours)

Thursday 9 August 1973

0900–1200 (Plantation Rm)	Subcommittee C Presentation CDR James E. Goodson, MSC, USN, Chairman
1200	Lunch
1330–1700 (Plantation Rm)	Subcommittee D Presentation Captain Robert E. Mitchell, MC, USN, Chairman
1700–1900 (Robt. E. Lee Rm)	Social Hour

Friday 10 August 1973

0900 (Plantation Rm)	Discussion: Navy R&D Management Issues Discussion leaders: Captain Roger G. Ireland Captain Robert E. Kinneman Captain Frank H. Austin
1100	Review of Conclusions and Final Report
1200	Lunch
1300–1400 (Plantation Rm)	Review as Required
	Concluding Address Captain Roger G. Ireland, MC, USN

APPENDIX B

TECHNICAL WORKSHOP ATTENDEES

Bureau of Medicine and Surgery

Captain Frank H. Austin, MC, USN
Captain Robert E. Kinneman, MC, USN
Captain Carl E. Pruett, MC, USN
Commander Paul D. Nelson, MSC, USN
Commander James E. Goodson, MSC, USN
Commander Paul E. Tyler, MC, USN

Chief of Naval Operations

Captain Roger G. Ireland, MC, USN

Office of Naval Research

Joseph P. Pollard, M.D.
Arthur B. Callahan, Ph.D.
Donald P. Woodward, Ph.D.
Gerald S. Malecki
Lieutenant Commander Kenneth H. Dickerson, MSC, USN

Naval Air Systems Command

Henry A. Fedrizzi
Commander Morris J. Damato, MSC, USN
Hyman Rosenwasser, Ph.D.
Earl B. Amey
Lieutenant Commander Paul R. Chatelier, MSC, USN
Lieutenant Commander Jimmie H. Johnson, MSC, USN

Naval Safety Center

Robert A. Alkov, Ph.D.
Captain Ernest C. Reed, MC, USN
Commander William V. Lassen, USN

Naval Aerospace Recovery Facility

Lieutenant Commander Donald H. Reid, MSC, USN

Naval Submarine Medical Laboratory

Charles Gell, M.D., Sc.D.

Commander, Naval Air Force, Atlantic Fleet

Captain Kenneth H. Reichardt, MC, USN

Commander, Naval Air Force, Pacific Fleet

Captain Marvin D. Courtney, MC, USN

Office of Naval Material

Arnold Rubenstein

Naval Air Development Center

Captain Laurence H. Blackburn, MC, USN
Dino Mancinelli
Harald J. von Beckh, M.D.
David Myres

Naval Missile Center

Lieutenant Commander Robert S. Kennedy, MSC, USN

Naval Aerospace Medical Institute

Captain Robert C. McDonough, MC, USN

Naval Aerospace Medical Research Laboratory

Captain Robert E. Mitchell, MC, USN
Captain Newton W. Allebach, MC, USN
Captain Channing L. Ewing, MC, USN
Ashton Graybiel, M.D.
Frederick E. Guedry, Ph.D.
Commander Thomas J. Gallagher, MSC, USN

University of Massachusetts

Gilbert C. Tolhurst, Ph.D.

APPENDIX C

A Review of

BIOMEDICAL AND HUMAN EFFECTIVENESS ISSUES IN PROJECTED NAVAL AVIATION PROGRAMS

Prepared by

James F. Parker, Jr.
Martin G. Every

Technical Workshop on
Biomedicine and Human Effectiveness
26, 27 July 1973

Bureau of Medicine and Surgery
Department of the Navy
Washington, D.C.

Foreword

This report was prepared under the direction of Captain Roger G. Ireland, MC, USN; Captain Robert E. Kinneman, MC, USN; and Captain Frank H. Austin, MC, USN; operating under the joint auspices of the Chief of Naval Operations and the Bureau of Medicine and Surgery.

The purpose of the report is to provide an overview of projected programs in naval aviation and to identify those biomedical/human effectiveness issues which it is felt will be of importance to program success. Initially, an attempt was made to classify future programs in terms of their introduction as follows:

Near Term - within five years
Mid Term - five to ten years
Long Term - ten to twenty years

Due to overlap plus lack of certainty as to the precise time at which programs will become operational, this classification scheme was not followed rigidly. However, an attempt is made to identify the approximate time frame for new programs as feasible.

The biomedical/human effectiveness issues which are identified are, for the most part, those suggested by program coordinators during the course of initial interviews. They are by no means considered to be exhaustive.

The following page lists the program coordinators and other persons who graciously contributed their expertise and time toward the purposes of this report and for whom a note of sincere thanks is due.

List of Contributors

V/STOL Aircraft Programs

CDR G.E. Matt, USN

Attack Aircraft Programs

CAPT J.C. Hill, USN
CAPT C. Fritz, USN
CDR H.A. Hope, USN

Fighter Aircraft Programs

CAPT J.C. Mitchell, USN
CDR W.B. Kirkconnell, USN

Helicopter/LAMPS Programs

CDR G. Crowell, USN
CDR F.M. Dreessen, USN

Patrol/ASW Programs

CAPT R.E. Burrell, USN
CAPT H.A. Zoehrer, USN
CAPT R. Kennedy, USN
CDR F. Duffy, USN

List of Contributors (Cont'd.)

Training Aircraft Programs

CAPT D.W. Nordberg, USN

CDR P.M. Cook, USN

CDR R. Phillips, USN

Survival Issues

LCDR W. Metzger, USN

Tactical/Nuclear Warfare

CAPT M. Varon, USN

CDR S. Stocking, USN

TABLE OF CONTENTS

Fighter Aircraft Programs

Mission

Future Navy fighter aircraft will have three basic mission assignments: fleet air defense, including the threat of cruise missiles as well as high altitude aircraft; air superiority, with considerable attention to a close-in "dog fighting" capability; and strike/fighter. At present, the close air support strike role for the Marine Corps is being partially fulfilled through use of V/STOL type of aircraft (the Harrier). It appears that V/STOL aircraft will play a significant role in the strike/fighter future of the Marine Corps and for the Navy's Sea Control Ship plans.

A single aircraft to meet the other two mission assignments (fleet air defense, air superiority) must be one with high Mach number, excellent maneuverability, and a high altitude kill capability. It must also carry both long and short range air-to-air missiles and a gun. The weapon control system must be one which can deal with multiple targets simultaneously.

Projected Vehicles

The principal fighter aircraft for the Navy and Marine Corps through the 1980's will be the F-14 Tomcat. Current plans call for an all F-14 fighter force, with other aircraft being transferred to Reserve VF Squadrons in a modernization move. Fiscal constraints may, however, require that a less expensive, less capable fighter than the F-14A be procured for half the Navy/Marine Corps fighter inventory. Efforts are ongoing within the Navy, at the request of the Deputy Secretary of Defense, to evaluate various alternatives to the currently planned 300 plus F-14A fighter force. Another type of aircraft being examined is a VTOL aircraft to handle the strike/fighter assignment, principally for the Marine Corps and Sea Control Ship.

The F-14 aircraft represents a significant advance over any previous fighter in terms of endurance, flexibility, maneuverability, and weapons control. It is superior to the F-4 it is intended to replace in terms of radar capability, tactical displays, variety of unassisted attacks that can be chosen, endurance, mixed weapons load, and airframe performance. The F-14 uses a two-man crew with the second officer in charge of weapon systems management. This leaves the pilot free to concentrate on aircraft maneuvering, particularly in close combat situations. Although the ceiling and maximum speed of the F-14 are not much different from those of the F-4, the variable geometry wing affords excellent performance through a wide range of speeds. For dog fighting, the F-14 has unexcelled maneuverability and excess thrust. This will give it unparalleled ability to train all its weapons on an adversary. Whereas the F-4 was at a disadvantage in the horizontal plane during dog fighting encounters with the more agile MIG's, the F-14 suffers no such disadvantage. The F-14 is superior to all known MIG aircraft in both horizontal and vertical engagements. Figure 1 shows the F-14 tracking an F-4 in a practice maneuver.

A significant part of the F-14's capability is derived from the Hughes AWG-9 weapons control system. The combination of the AWG-9 with the associated Phoenix air-to-air missile allows the aircraft to attack multiple targets simultaneously as well as to counter high altitude threats posed by aircraft such as the MIG-25. The AWG-9 is a partially redundant weapons control system containing two major sensors: a pulse Doppler search, track, acquisition, and guidance radar and a gimbal-mounted infrared search/acquisition sensor. It includes a high-speed digital computer, and a pair of displays and various controls for the rear seat Naval Flight Officer. This long range system provides high volume coverage nine times that of the F-4. Radar range for comparable sized targets is estimated at two to two and one-half

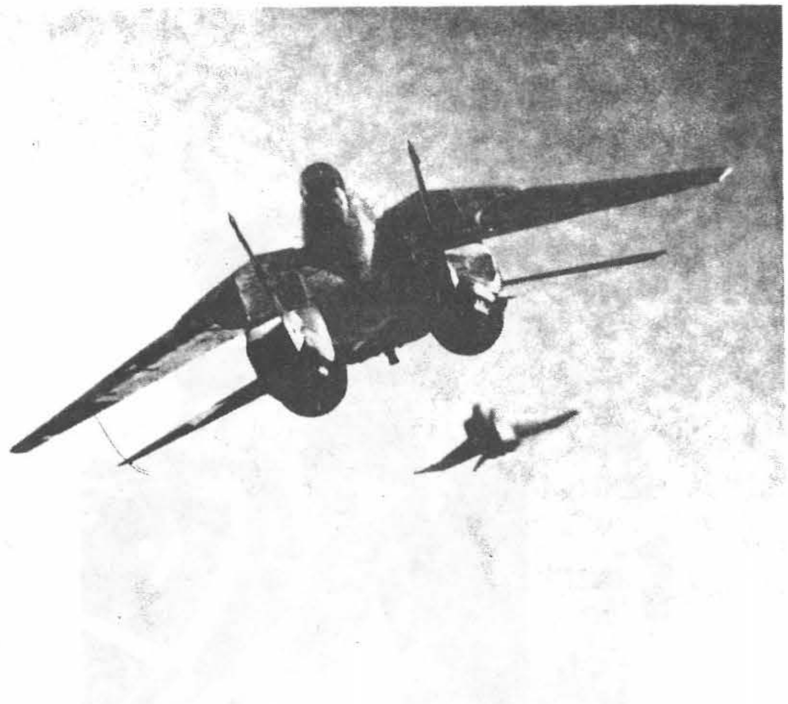

Figure 1. F-14 aircraft pursuing an F-4 during Air Combat Maneuvering (U.S. Navy photograph).

times the F-4. In the track-while-scan mode, the AWG-9 can track 24 separate targets simultaneously. The radar handles target detection, tracking, and ranging for all F-14 air-to-air weapon loads. These can be six long range Phoenix missiles, six shorter range Sparrow missiles, or some mix of the two missiles, plus four Sidewinder heat-seeking missiles, and the high-rate-of-fire Vulcan 20 mm cannon, as well as ranging for air-to-ground stores (Aviation Week and Space Technology, 12 March 1973).

Figure 2 shows the cockpit panel of the F-14 for the Naval Flight Officer. The center display presents computer-generated information in coded symbols and numerics depicting the air scene, based on data acquired by the aircraft's pulse Doppler radar and infrared sensor as well as data link information. Raw radar video and infrared data are presented on the upper cathode ray tube. At the right of the panel is an electronic countermeasure display.

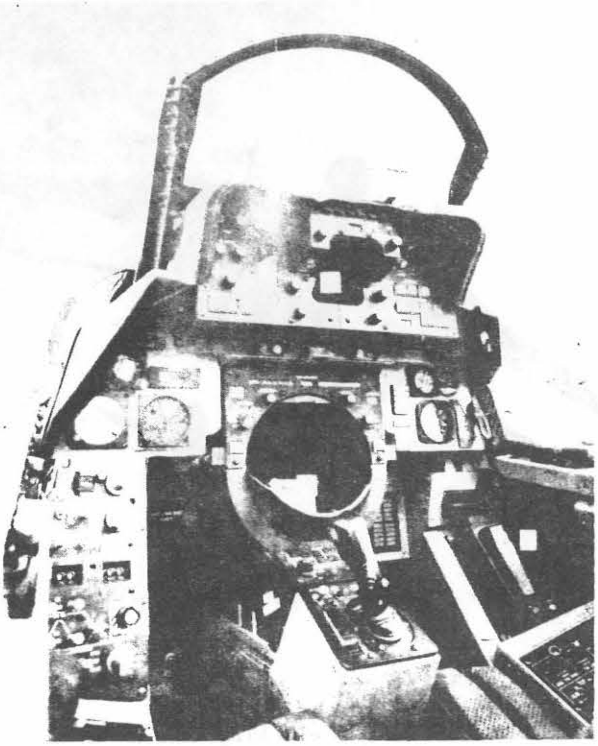

Figure 2. Rear seat displays in F-14 aircraft (Aviation Week and Space Technology, 12 March 1973).

Biomedical/Human Effectiveness Issues

1. Acceleration Profiles. The sustained normal acceleration of the F-14 are excellent and represent a significant increase over other aircraft, particularly at altitude. For example, the F-14 can sustain a 5 G loading at high altitude for as long as the pilot desires. It can also pull much higher instantaneous and sustained G forces in combat maneuvering throughout most of its envelope. This means that in a combat deployment, pilots will be subjected on a regular basis to a mechanical force environment of greater intensity than now experienced. While it is obvious that the F-14 can be successfully flown throughout its performance envelope without injury to the pilot, what the physiological price of repeated exposures to sustained acceleration forces of this

magnitude will be is not known. However, the price may be such that new procedures and equipment for acceleration protection should be investigated. In any event, the first step must be one of determining the long term physiological impact of operating in the force environment provided by the F-14.

2. Physical Fitness. The general physical condition of a pilot makes a real difference in the manner in which he flies an aircraft such as the F-14. One must be in excellent physical shape in order to perform at optimum effectiveness during aerial combat. The abrupt changes in G forces, the constant scanning of both the sky and the cockpit, the concentration on the flight path of the enemy craft, and the continued alert for surface-to-air missiles, all require peak physical performance. Unfortunately, life aboard an aircraft carrier does not contribute much to physical fitness. Exercise facilities are limited and life, other than flying, is somewhat sedentary. There is a need, therefore, and particularly for pilots of high performance aircraft such as the F-14, to develop techniques which will allow them to remain in top physical condition. There also is a requirement for procedures whereby Medical Department personnel can make a rapid determination of the state of an individual's physical fitness at a given point in time.

3. Selection and Training of NFO's. The Naval Flight Officer in the rear seat of an F-14 is a very vital element. His job is quite complex and requires close coordination with the pilot. Mission success, particularly when dealing with multiple targets at long range, is very much dependent on the performance of the NFO. It becomes quite important, then, that proper selection and training procedures be established that will ensure that the F-14 NFO can work well with the pilot and can meet the stringent demands of combat missions. This may not be an easy task. Initial reports from the first class of F-4 NFO's now being trained for assignment to F-14's is that about half of them are having a very difficult time in moving up to the F-14.

4. <u>Personal Equipment</u>. F-4 pilots, now moving into the F-14, foresee no great need for a pressure suit for use with this aircraft. They do express great interest, however, in getting rid of the current aviator's helmet and oxygen mask, or at least in developing an improved and lighter weight version. The problem is serious enough that, at present, a number of pilots have been known to remove both the helmet and oxygen mask during Air Combat Maneuvering. Communications are maintained through use of a lip microphone. The big difficulty, of course, is that the helmet and mask tend to slide so as to inhibit both the pilot's field of view and communications capability and to force the head down during the various accelerations of ACM.

The negative G capability of our fighter aircraft could be more gainfully exploited if seat restraint systems were optimized. This same optimization is needed in the torso restraint systems. Present shoulder harnesses inevitably "lock" during dog fights (due to the automatic "G" locking systems) and present real problems for the pilot who must continually move his torso forward and backwards while looking around at or for an adversary.

Attack Aircraft Programs

Mission

The mission of attack aircraft in the future will remain much as it is now: to deliver weapons to designated enemy surface targets and installations. The aircraft must be capable of penetrating enemy ground and ship defenses over quite long ranges and must be capable of accurate delivery under day/night and all weather conditions. In addition, the basic attack aircraft of the future must possess some measure of self-defense against enemy fighters and missiles.

The basic attack aircraft will be complemented by a medium all-weather attack aircraft which will be even more sophisticated in character and which will be capable of standoff missile attack. It seems, however, that most attention in the immediate future will be directed toward improving the basic attack aircraft.

Projected Vehicles

The two attack aircraft projected for use through the 1980's are the E versions of the A-6 Intruder and the A-7 Corsair 2. The A-6 aircraft is a two-place, subsonic vehicle with an all-weather delivery capability. The A-7 is a single-place, subsonic vehicle used for VFR deliveries. The A-6E and A-7E aircraft are markedly improved over earlier models, although few changes accrue to the basic airframes. New navigation and delivery systems are provided which significantly increase overall attack capability. It has been estimated, for example, that the A-6E will achieve a tenfold increase in reliability and maintainability over the earlier A-6, while the A-7E offers an estimated sevenfold capability in target destruction effectiveness due to improved accuracy.

The greatly improved weapons delivery capability of future attack aircraft will come through the use of state-of-the-art sensor packages which will allow precision attack at night and under all weather conditions. Much of this improvement will be provided by the Forward Looking Infrared (FLIR) Sensor. The FLIR sensor system depends on the passive detection of IR energy resulting from variations in temperature of the ground, water, or such objects as men, vehicles, and structures. These sensors work better at night, when warm bodies stand out more clearly against the cooler ambient temperatures and when human vision is restricted by darkness, than during the day. But in daylight, they can spot camouflaged vehicles or guns. They can, for example, detect a submarine periscope in total darkness from the temperature gradient in the periscope's wake (Aviation Week and Space Technology, 7 May 1973). Figure 3 compares a FLIR image with that of a scene taken with conventional photography.

FLIR's ability to provide a high quality cockpit display at night, in an entirely passive manner without resort to any illumination or aircraft-generated emissions, makes it excellent for use in night surveillance, target acquisition, and weapons delivery. Although the IR reception is somewhat degraded in fog and haze, it still retains an advantage over unaided vision. The IR range under these conditions may be improved from zero to three times over normal visual range.

The complete system to be installed in A-6E and A-7E attack aircraft is known as the Target Recognition Attack Multisensor (TRAM) Self-Contained Day/Night Attack System. This system includes the FLIR sensor, which on the A-6E is colocated with a laser designator/range finder, laser forward air control receiver, and a laser ranging receiver. The aircraft can use both radar and electro-optical sensors to locate and designate targets for self-released laser weapons on a single pass. A second cathode ray tube display at the BN position allows simultaneous comparison of the radar and FLIR pictures. The system for use in the

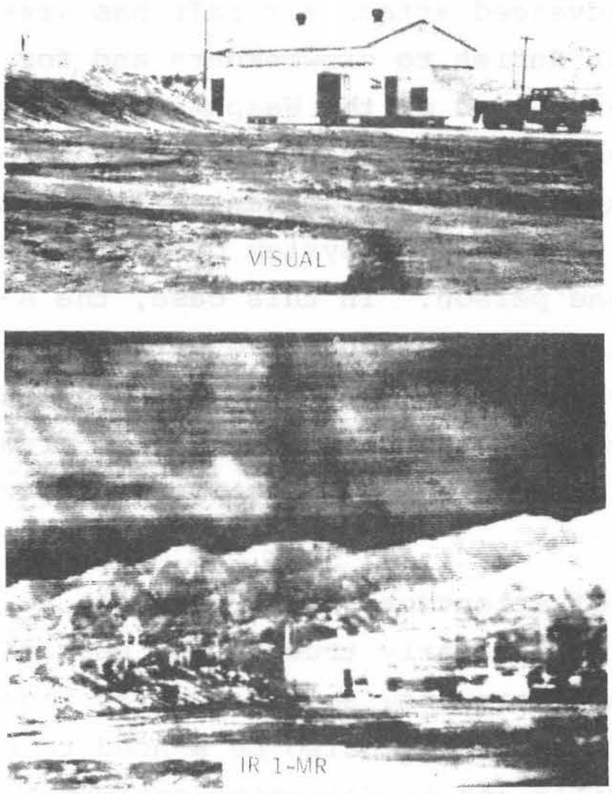

Figure 3. Comparison of conventional photograph with image provided by FLIR sensor (Aviation Week and Space Technology, 7 May 1973).

A-7E will be slightly less complex but will contain essentially the same elements.

Biomedical/Human Effectiveness Issues

1. Training and Crew Loading. The A-6E and A-7E aircraft represent several orders of magnitude increase in the sophistication of navigation, target acquisition, and weapons delivery equipment. Monitoring and operating this equipment will place an increased burden on crewmembers as they must deal with increasingly complex cockpit instrumentation. This burden will continue to grow in the future as the time approaches when a strike force will consist of a single aircraft assigned multiple missions during the strike.

The nature of advanced attack aircraft has great implications for the assignment of duties to crewmembers and for their training. The increasing burden placed on the Weapons System Officer may require that, in the A-6E, some part of these labors be assumed by the pilot. In the A-7E, where at present a single individual serves as both Pilot and Weapons System Officer, the task may become too great for one person. In this case, the A-7E two-place trainer version could be reconfigured to serve as the operational aircraft. It is obvious, in any event, that considerable attention must be given to crew task loadings and to crew coordination if the new delivery systems are to function with maximal effectiveness.

The same level of attention should be given to training issues. This will be particularly true in the upgrading of current attack pilots who must learn new skills such as radar target interpretation, etc. There will also be a need to examine the hierarchy of crew skills and to determine optimum training procedures for each. For example, control of the aircraft as a ballistic delivery platform may become a lesser issue than that of target acquisition at night. In this case, utilization of training facilities such as the Fallon Range would be altered, with a need to position various targets along routes unfamiliar to the pilot in training.

2. Display Requirements. The various components contained in the two TRAM systems require the display of new information to crewmembers. It has been recommended, particularly in the case of the A-7E pilot, that additional support be devoted to the development of lightweight helmet display systems in which the required information might be shown, for example, directly on the visor of the pilot. Such new display systems will be readily accepted, however, only if they result in zero increase or preferably in a reduction of total helmet weight.

Along the line of new display systems, interest has been expressed in the development of new cockpit lighting systems which would reduce the current problems of reflections from instrument lights impairing vision through the windscreen at night. The suggestion has been made that light enhancing devices, possibly incorporated in the lenses of a goggle system, be used so that cockpit instruments might be viewed at night without an internal lighting system.

3. Special Weapons Problems. It is anticipated that, when the TRAM systems are fully operational, nuclear deliveries may be made with the Thermal Radiation Shield closed for the entire period of the mission. This being the case, attack pilots do not recommend special goggles or sensors to deal with flash blindness or thermal radiation problems. The only significant problem which is anticipated is from the blast effects from weapons detonated in relative proximity to the flight path. However, in a nuclear environment, it is possible that EM pulses could do strange things to the electronics of the navigation and delivery systems. Should this happen, a pilot would be required to revert to essentially a dead reckoning approach to the target. This would be quite difficult and would increase his workload greatly. It also would once again expose him to the flash blindness and thermal radiation problems.

V/STOL Aircraft Programs

Mission

The Navy is presently conducting a continuing evaluation of the Interim Sea Control Ship aboard the U.S.S. Guam (LPH-9). The concept of the Interim Sea Control Ship is one in which both helicopters and V/STOL aircraft operate from a small austere ship, in effect a small aircraft carrier. This ship has an entirely different mission than the attack carrier, however, and will be used principally to escort high value convoys or forces without carrier protection. At the present, SH-3G helicopters and AV-8A (Harrier) aircraft are being used in the evaluation.

The Navy aircraft spectrum of the future calls for a small strike/fighter to complement the fleet air defense fighter. This aircraft will be capable of supersonic speed and will have at least a 500 nm operating radius. In view of recent rapid advances in V/STOL aircraft technology, it now is felt an aircraft of this type could well fill the role of strike/fighter for the Marine Corps and the Navy.

Projected Vehicles

The V/STOL aircraft likely to see most use in the near term is the AV-8A Harrier. The two Marine Corps squadrons outfitted with this aircraft in 1972 now are developing procedures for its use in support of Marine Corps missions. The aircraft, of British manufacture, is single-place, although a two-place trainer version is available. It is a fairly light aircraft, having a gross weight of 25,000 pounds, or about half that of the A-7E. It has a thrust of 21,500 pounds, giving it a thrust-to-weight ratio of almost 1:1 under many loading conditions. This allows excellent longitudinal acceleration, superior to that of current fighter and attack aircraft.

This aircraft features a single lift/cruise engine which diverts the fan thrust through two movable forward nozzles and the exhaust gases through two aft movable nozzles. These nozzles are controllable at any angle from full aft to 12° forward of the vertical and all move in unison. Roll, yaw, and pitch control are maintained by a reaction control system that is mechanically linked to the normal flight control system and powered by bleed air from the engine.

At speeds above 150 knots, flight in the Harrier is no different from that in other jet aircraft. During takeoff and landing and during the critical transition speed between 80 and 120 knots, however, the problems of flying a Harrier are significantly different. A brief description of the 350-foot launch run on a Sea Control Ship illustrates this difference. The launch role is begun with nozzles set at a 10° down deflection angle. Most of the thrust is longitudinal and results in an approximate 32 ft/sec^2 acceleration. At the 300-foot mark, the nozzles are deflected (almost instantaneously) to 60° down, causing 80 percent of the thrust to shift to the vertical and the resulting longitudinal acceleration to drop to one-half its previous value. The aircraft seems to pop into the air and also gives a distinct impression of engine failure. It is a tricky and frightening maneuver and one which will require considerable training, particularly if night launches are to be made from the SCS.

There are two very useful features of the Harrier that give this aircraft excellent self-defensive capabilities. One of these is the ability to select reverse thrust inflight. While most aircraft use idle power and speed brakes to decelerate, the Harrier used reverse thrust. Not only is reverse thrust more effective in that it provides greater deceleration than speed brakes, but its application is also very difficult to detect by the pilot of another aircraft. Whereas speed brakes can be readily seen,

movement of the nozzles beneath the wing cannot. Another feature unique to the Harrier that will be useful and will be available to future aircraft with reaction controls is the capability to precisely control nose and wing position in extremely low speed flight.

A candidate for the mid-term VTOL aircraft is the Thrust Augmented Wing, a prototype of which now is being built for the Navy by North American Rockwell. This aircraft will be capable of vertical takeoff and landing as well as supersonic flight. It is easily identified by the forward mounted low canard and a high mounted wing aft that has a pair of vertical stabilizers mounted on the tips of the wing extending both above and below the wings. The aircraft obtains a vertical lift by blocking the entire jet efflux into an annular diverting ring that routes the air into augmenting devices located in each of the wings and canards via longitudinal plenum chambers. A mockup of the first prototype is shown in Figure 4.

Figure 4. Mockup of Thrust Augmented Wing aircraft (Aviation Week and Space Technology, 5 February 1973).

The Thrust Augmented Wing aircraft will be capable of 7 G throughout the entire flight envelope. At 35,000 feet, it will be able to maintain a 5 G turn at Mach 1.6. This is a quantum jump forward from current aircraft. The F-4, for example, has only a 1.3 G capability at that altitude and speed. The Thrust Augmented Wing also has the possibility for very high speed. In the supersonic regime, the Wing can be made very clean because the "augmenters" fold up into a neat package that is favorable to supersonic flight.

Current thinking is that the Thrust Augmented Wing (XFV-12A) might become operational by 1983. Fabrication and flight testing of two prototype aircraft is expected within the next three years.

Biomedical/Human Effectiveness Issues

1. Training. Possibly the most important pilot oriented problem associated with the coming generation of VTOL aircraft is that of training. In many respects, these aircraft will be quite different from those currently in use. Handling qualities inflight, launch and recovery procedures, weapons deliveries, air-to-air encounters, all will be changed. New training techniques must be developed for use with new aviators and also (and this may be quite important) for those aviators transitioning from current aircraft. New simulators obviously will be needed. It also may prove advantageous to use centrifuge facilities more extensively as training devices in order to demonstrate and to train in the unusual acceleration profiles which can be encountered with VTOL aircraft.

Training in all-weather landing procedures also will be quite important. At the moment, there is not a clear understanding of the precise cues and information needed by a pilot to make a vertical landing under conditions of reduced visibility.

2. Escape. The Harrier aircraft is equipped with the Martin-Baker ejection seat. The pilot has 13 separate attachment points to the seat and ancillary support equipment. In the event an aircraft were to go over the side of the ship into the ocean, it would be quite difficult for a pilot to relieve himself from this myriad of fittings in time to escape. A single point attachment system would be of great benefit.

3. Disorientation. During a vertical landing on a rolling ship, disorientation could be a real problem. Earlier experience with previous VTOL aircraft showed that the unusual viewing angle of the pilot could produce vertigo and disorientation to the point of effective incapacitation.

4. Presentation of Information. The piloting of VTOL aircraft represents a very new type of flying. Flying the aircraft under Visual Meteorological Conditions (VMC) presents no big problem; however, the Instrument (IMC) transition from jet-borne to aerodynamic flight and vice versa is the real area of concern. To do this properly, new techniques of information presentation (HUD, visor projection displays, etc.) may be required. In addition, new items of information may be needed. For example, several aircraft have been lost apparently as a result of greatly increased lift on the upwind wing during a crabbed landing. As lift on the downwind wing approaches zero, the aircraft suddenly rolls inverted and crashes. It may be necessary to provide the pilot with a continuous indication of the lift component on each wing during certain landing approaches. In any event, the items of information to be presented and the proper techniques for such presentation in VTOL aircraft represent an area worthy of investigation.

Patrol/ASW Aircraft Programs

Mission

Navy land-based patrol aircraft will continue all weather ocean search in an effort to detect enemy submarines, identify and photograph ships, and observe shipping lanes and the movement of enemy warships. These aircraft will possess an array of weapons, giving them the capability to find and destroy enemy submarines. The future mission of patrol aircraft will remain basically the same as it is now, with increased emphasis on greater range, and increased ASW sensor system capability.

Carrier-based fixed wing ASW platforms are to be an integral member of the CV air wing. The future mission of these aircraft will remain as now: to detect and attack enemy submarines. Additional requirements for future ASW aircraft may include self-protection against long range surface-to-air missiles and compatibility with standoff weapons in order to augment attack aircraft in an anti-surface ship role.

Projected Vehicles

The P-3C will be the primary aircraft for land-based ASW patrols through the late 1980's. Although no changes are planned to the basic airframe, continued improvement in detection, localization, classification, and attack equipment will insure that this aircraft remains a highly technical and sophisticated platform. Future VPX aircraft will probably use an existing airframe so that the emphasis on funding can go to improving ASW sensor subsystems.

The S-3A (see Figure 5) is currently replacing the S-2 as the primary fixed wing carrier-based ASW aircraft. The S-3A is only slightly larger than the S-2E, but it has a more advanced weapon system and significantly greater performance due to the two 9,275-lb thrust turbofan engines. The operating characteristics

of the S-3A include: ceiling--40,000 ft; maximum dash speed--440 kt; combat range--2,000 nmi; rate of climb--4,200 fpm. The S-3A includes a 4-man crew. Emergency escape from the aircraft is by ejection seat. The S-3 is projected for use through the 1980's.

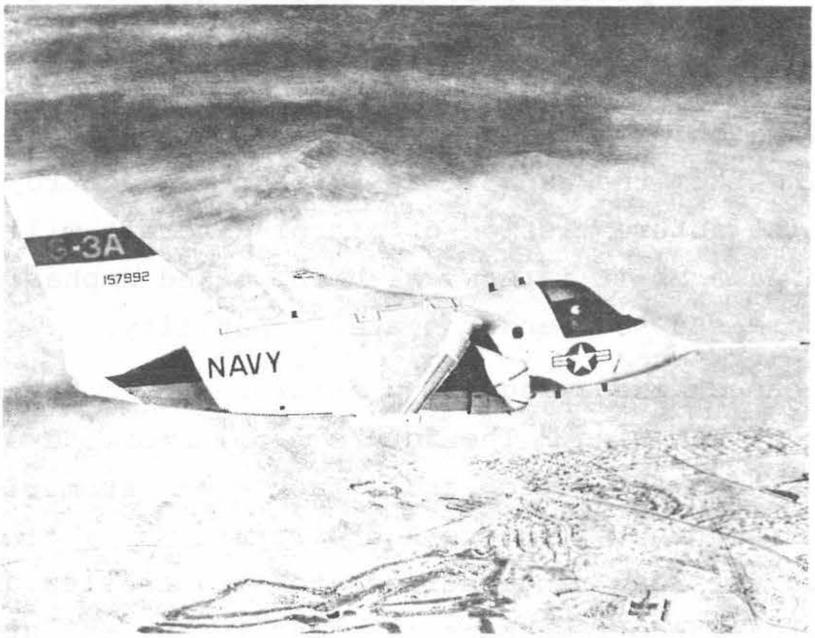

Figure 5. S-3A ASW aircraft (Aviation Week and Space Technology, February 14, 1972).

Advanced ASW programs being considered include the possibility of using modified VSTOL/VTOL aircraft. This would allow the system to be optimized for ASW while collaterally serving an anti/ship-aircraft missile role.

Biomedical/Human Effectiveness Issues

1. Fatigue. P-3 patrol missions normally range from 10-12 hours in length, with some missions lasting up to 16 hours. The total number of flight hours per month in a VP squadron averages 65-70, and can go over 100 when the squadron is deployed. This is about 2.5 times the flight hours of fighter pilots. For the S-3 aircraft, mission time will be approximately 6 hours, with the

crewmen sitting in ejection seats for the entire time. Although a S-3 crewman can get out of his seat, there is no opportunity to move around in the aircraft. These lengthy missions for P-3 and S-3 crews could allow fatigue, and in some instances boredom, to become major problems. Ozone odors associated with some electronic equipment, plus high noise levels, in some cases above 90 db at certain points in the P-3 and S-3 mission profiles, could contribute to the fatigue situation.

The fatigue problem in patrol and carrier ASW aircraft should be investigated for its possible role in reducing performance effectiveness. When ASW crews return from a mission, they still may have maintenance and other responsibilities to fulfill, all of which can contribute further to cumulative fatigue. If fatigue is judged to be a serious problem, consideration might be given to a reduction in collateral duties as one step toward improving the situation. Another, and more direct biomedical issue, is the need to develop better indices of fatigue so that the point at which performance is likely to degrade can be predicted with some accuracy.

2. <u>Protective Clothing</u>. Missions to be flown by the S-3 could be at considerable distance from any other aircraft or possible rescue force and over water. In the event of emergency escape from the aircraft, it might be necessary to survive in cold water for several hours prior to rescue. Anti-exposure clothing, therefore, is a requirement. However, due to the long nature of ASW missions any protective clothing which is used should not cause discomfort. A very careful balance must be maintained between protective effectiveness and operational comfort. Work should continue toward the improvement of current protective garments.

3. Cockpit Lighting/Control Arrangement. The requirement for external vision in a VS aircraft at night, coupled with the instrument lighting and resulting internal reflections, can give rise to pilot disorientation. Any lighting systems or vision enhancing devices which would alleviate this situation could make a contribution to aviation safety. The first step in a program of correction, however, would be to ascertain the exact extent of the problem and to pinpoint those places in a mission profile where the disorientation is most likely to occur. There is also evidence to suggest that inconveniently located equipment requiring in-flight resetting has led to crew disorientation.

4. Crew Monotony. In an ASW mission, certain crewmembers spend long periods of time monitoring cathode ray tube displays. The monotony of this operation can result in reduced effectiveness. It has been suggested that multicolored display systems might be of some benefit in reducing the monotony. Any technique which results in maintaining performance at the desired level would be beneficial.

5. Flight Clothing. Crewmembers of the P-3 aircraft have expressed dissatisfaction with the current flight suit. They make the point that P-3 flights are an airline-type operation and that the aircraft are clean. They feel that morale factors would be enhanced through the use of a dressier "double-knit" flight suit designed principally for appearance rather than for protective qualities.

Helicopter/LAMPS Programs

Mission

Anti-submarine warfare (ASW), assault, transport, attack, vertical replenishment, reconnaissance, and search and rescue (SAR), are and will continue to be the basic missions of the helicopter. These missions are now being expanded to increase the versatility and capability of the surface ship. This union, the Light Airborne Multi-Purpose System (LAMPS),provides a manned helicopter to augment the destroyers' weapons system, and is designed to accomplish two primary missions: ASW and Anti-Ship Missile Defense. The future missions of the helicopters will be somewhat controlled by the success or failure of VTOL fixed-wing aircraft now being introduced into the fleet.

Projected Vehicles

A "Seasprite" helicopter was modified to become the LAMPS MK I vehicle. Designated the SH-2F, it will be the light ASW helicopter. It houses a search radar in its nose and on the starboard pylon is a winch to deploy a magnetic anomaly detector (MAD) (see Figure 6). It also carries launchers for the MK-46 ASW torpedo. A three-man crew will man the SH-2F; pilot, co-pilot and a third crewman who will operate a control console, monitoring and interpreting signals received from sensors. The LAMPS MK III aircraft is scheduled to enter the fleet by 1981.

The SH-3 heavy helicopter will continue to serve the aircraft carriers; however, the Sea Control Ship (SCS) concept will necessitate the early introduction of a new VTOL aircraft (HSX) which should have an initial operational capability at least by the early 1980's. The requirements for these aircraft will be determined as SCS needs are defined.

Figure 6. LAMPS MK I helicopter (SH-2)

Biomedical/Human Effectiveness Issues

1. Training. The LAMPS and SCS concepts provide new mission profiles and new tasks for helicopter pilots and crews. There will be a wide range of assignments. For example, a LAMPS crew may be assigned an ASW mission, an anti-ship missile defense role, or other missions involving reconnaissance, vertrep, medivac, personnel transfer, search and rescue, tactical gunfire support, and still others. In view of these multiple roles, the establishment of an efficient training program and the development of techniques for maintaining proficiency in these diverse assignments will be quite critical for the success of the LAMPS program.

The LAMPS training program will need to be efficient in terms both of utilization of trainees and of instructor personnel. The LAMPS program could conceivably involve training of 4,000 individuals. The training load on the helicopter flight training command will be quite heavy.

2. Escape Systems and Helicopter Crashworthiness. HS helicopters generally operate at quite low altitudes over water. Techniques allowing immediate egress from such helicopters need to be continually reviewed in light of the very short period of time in which one can escape from a sinking vehicle. Whereas the SH-3 helicopter has flotation bags, the SH-2 does not. When the SH-2 was designed from the older H-2 airframe, it was necessary to remove the flotation bags in order to accommodate new equipment. One can anticipate that the flotation time for SH-2 helicopters will be quite short.

Attention also should be given to the crashworthiness of these vehicles. This implies impact absorbing seats, fire retardant materials, appropriate egress avenues within the vehicle, emergency lights, and, above all, adequate training for emergencies and emergency escape.

3. Human Engineering. There are a number of human engineering issues which should be considered in the design of future ASW helicopters. Problems that now exist with the HS-2 can provide useful guidelines. For example, in the SH-2, the pilot pulls back to actuate the main rotor brake control. In the SH-3, he pushes forward to actuate this same control. The opportunity for negative transfer is obvious.

The newer helicopters are making increasing use of vertical strip displays for cockpit information presentation. This is excellent for such variables as temperature and pressure. For rotor rpm, strip displays may not be advisable. In this case, pilots suggest that a standard round dial with moving pointer will give a quicker indication of change in output and, thus, will allow a more rapid detection of a critical change in power.

Finally, the co-pilot's seat in the SH-2 helicopter is nonadjustable, either horizontally or vertically. This can contribute to discomfort and increase the fatigue factor during long flights.

Training Aircraft Programs

Mission

The objective of the Naval Aviation Training Program is to provide personnel qualified to operate new and projected aircraft and to accomplish those missions assigned to naval aviation. As the demands and complexity of naval aviation increase, the training program must be continuously updated, with advances in training technology incorporated into the system as rapidly as feasible. This includes use of simulators and other forms of training equipment. The updating also includes the training aircraft. Training aircraft of the future will require low operating costs, ease of maintenance, high MTBF components, and a high degree of inherent safety.

Projected Vehicles

Two new training aircraft are to be procured in the near future for the Chief of Naval Air Training. The first of these will be the VT/PX aircraft, a replacement for and very similar in appearance to the T-34 Mentor aircraft now in use as a basic trainer. Every naval aviator will receive his first 65 hours of flight training in the VT/PX. This aircraft will be very much like the T-34 (shown in Figure 7), but will use a turboprop engine and will be approximately 1,000 lbs heavier. One of the big differences to be found in use of this aircraft over earlier training aircraft is that an oxygen system will be used virtually from the first flight. One of the advantages of the VT/PX is that it will open up the air space from 10-20,000 feet for training purposes.

The VT/PX aircraft will have neither a pressurization system nor air conditioning. Neither will there be an extraction system for the pilot. However, inasmuch as the aircraft can be flown at fairly low speeds, either a sea ditching or an over-the-side bailout is possible in the event of an in-flight emergency.

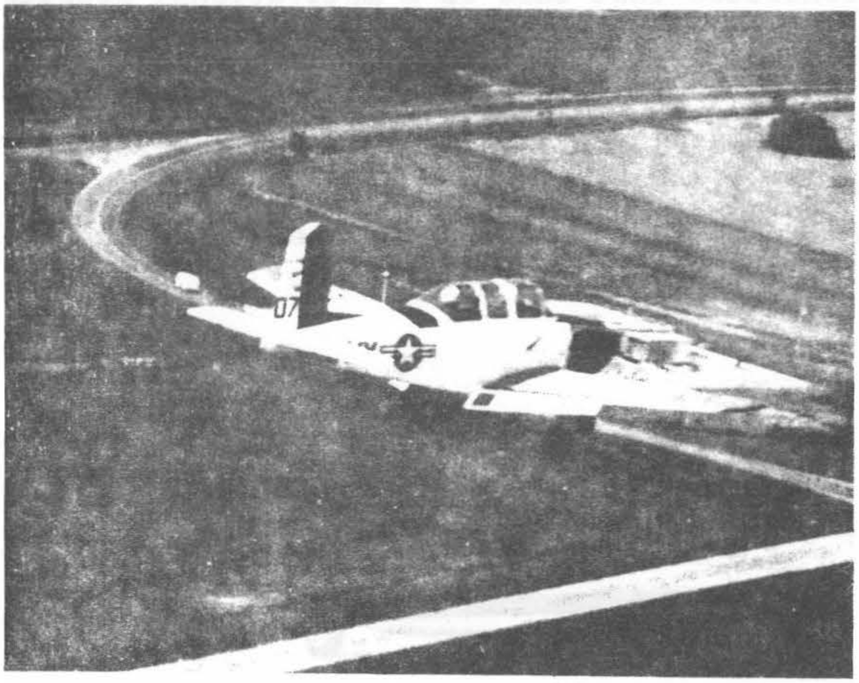

Figure 7. T-34 Mentor basic training aircraft (U.S. Navy photograph).

The future multi-engine training aircraft, to be procured as an off-the-shelf item in the 1975-1977 time-frame, is known as the VTAMX. It will be a medium twin turboprop aircraft similar to the Beech KingAir or the Aero Commander 690, shown in Figure 8. The aircraft will be pressurized and will carry two pilots and four students. It also may be used as a replacement vehicle for the T-39 in its role in the training of Naval Flight Officers.

Biomedical/Human Effectiveness Issues

1. Aviator Selection. Although continuing efforts are being made to refine the selection criteria for naval aviators, the attrition rate for those who drop from the program at their own request

(DOR's) seems to remain consistently at about 28 percent. It is generally concluded that this is a motivational problem rather than any sudden realization on the part of an individual that he is maladapted to fly. This being the case, work should continue in an effort to identify these motivational issues prior to the commencement of flight training. Any reduction in the number of DOR's would have a significant cost-benefit for the training program.

Figure 8. Aero Commander 690 under consideration as future multi-engine training aircraft.

2. <u>NFO Selection</u>. The establishment of existing selection criteria for Naval Flight Officers remains a problem. It is felt by some that there simply are certain individuals who have an innate capacity for visualizing a three-dimensional situation from a two-dimensional display, coupled with certain aural information. Whether this capacity exists as a unique human trait is a matter for further consideration. However, the extensive job demands of new aircraft such as the F-14 and the A-6E require the highest order of skills and capabilities from NFO's. Work must continue on the development of selection criteria to insure that individuals are chosen with maximal chance for success.

APPENDIX D

GLOSSARY

ACM	Air Combat Maneuvering
AGL	Above Ground Level
AOM	Aviation Operational Medicine
BTU	British Thermal Units
BW/CW	Biological Warfare/Chemical Warfare
FFBD	Function Flow Block Diagram
FLIR	Forward Looking Infrared
HE	Human Effectiveness
HF	High Frequency
HFE	Human Factors Engineering
IR	Infrared
LAMPS	Light Airborne Multi-Purpose System
LED	Light Emitting Diode
LOX	Liquid Oxygen
LS	Life Support and Survival Systems
MTF	Modulation Transfer Function
NAACH	Nonacoustic Audio Coupling to Head
NADC	Naval Air Development Center
NAMRL	Naval Aerospace Medical Research Laboratory
NARF	Naval Aerospace Recovery Facility
NRC	National Research Center
OSD	Operational Sequence Diagrams
PA	Physiological Assessment
RAG	Readiness Air Group
SAR	Search and Rescue
SAT	Systems Approach to Training
SNRD	Signal to Noise Ratio at the Display
T&E	Test and Evaluation
TOT	Transfer of Training
VA	Attack Squadron
VCS	Visually Coupled Systems
VF	Fighter Squadron
VFR	Visual Flight Rules
V/STOL	Vertical/Short Takeoff and Landing
VTAS	Visual Target Acquistion System

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13. ABSTRACT This document represents the final report of the Fiscal Year 1974 Naval Aviation Biomedicine/Human Effectiveness Technical Workshop, which met to review Navy RDT&E programs in support of aviation medicine and to make recommendations regarding objectives and priorities for future research. This Workshop included both members of the user community (Fleet aviation personnel and aviation planners) and the producer community (RDT&E scientists and engineers) for the exchange of relevant information relating to the conduct of Navy research programs in support of aviation medicine.

The first part of the Technical Workshop consisted of a two-day briefing held in Washington, D.C. Naval personnel concerned with aviation planning programs described the advanced technology and prospects for future naval aviation systems. They also discussed the biomedical and human effectiveness issues they felt would be raised through use of these new systems. The Technical Workshop itself was held ten days later. The work of the conference was done by four subcommittees covering the content areas of (1) Aviation Operational Medicine, (2) Physiological Assessment, (3) Life Support and Survival Systems, and (4) Human Effectiveness. Each committee presented conclusions relating to its specialized field of interest.

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